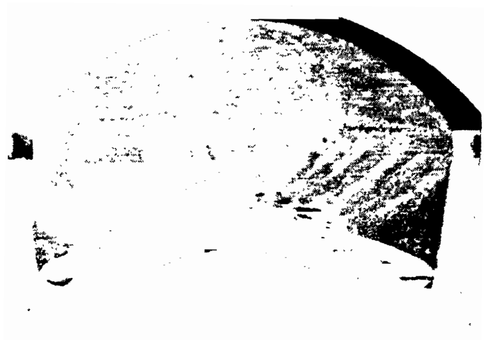
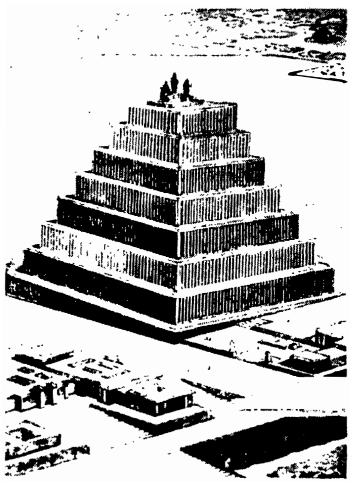
History of Science Library

EDITED BY PROFESSOR A. WOLF

EARLY ASTRONOMY AND COSMOLOGY



THE WORLD AS CONCEIVED BY THE CHALDEANS
(From Maspero's *Dawn of Civilization*)



CHALDEAN TEMPLE AT KHORSABAD
(From Perrot and Chipiez: *Histoire de l'Art dans l'antiquité*)

EARLY ASTRONOMY AND COSMOLOGY

A RECONSTRUCTION OF THE EARLIEST COSMIC SYSTEM

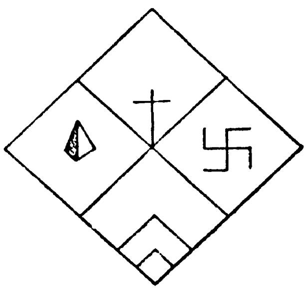
by

C. P. S. MENON

B.A. (Hons., Madras) M.Sc.(Lond.), F.R.A.S.

WITH A FOREWORD BY

PROFESSOR L. N. G. FILON, D.SC., F.R.S.



LONDON

GEORGE ALLEN & UNWIN LTD

MUSEUM STREET

FIRST PUBLISHED IN 1932

PRINTED IN GREAT BRITAIN BY
UNWIN BROTHERS LTD., WOKING

FOREWORD

It is peculiarly appropriate that the first volume of this new series of monographs on the History of Science should deal with the beginnings of Astronomy. The recurrence of the phenomena of the heavens first taught mankind that regularity and law existed in Nature, and, from the shepherds who saw the morning star rise in the Chaldean dawn to the research workers who measure on spectrograms the velocity of incredibly distant nebulæ, the watchers of the sky have ever been foremost in opening to the human mind fresh possibilities and wider horizons. Astronomy is still, in a sense, the most fundamental, as it is the oldest, of the sciences, so much so that its history, at any rate down to the seventeenth century, occupies the greater part of the general history of Science.

With its development is closely bound up that of Mathematics, and, in the earliest stages, the two cannot be studied independently.

It is gradually beginning to be realized that many of the achievements of Greek culture in this field did not spring, fully armed, from the Hellenic brain, but had their more remote origins in the civilizations of the ancient East. There is here a region of research which, as yet, has barely been explored. It is a region full of difficulties and pitfalls, in which the explorer needs to be equipped, not only with the tools of the archæologist, but with the vision of the astronomer, two qualifi-

cations which are but rarely combined in the same person.

Mr. C. P. S. Menon, the author of the present work, happens to be particularly well suited to undertake such a task. A graduate of both an English and an Indian University, he adds, to technical astronomical knowledge, that peculiar instinct for interpreting the Eastern mind and its ways which is essential in work of this kind, and which can only be found among those who have grown up in the environment of an Eastern civilization.

Indeed he describes, in Chapter II, the curious observation that originally led him to the theory which forms essentially the subject of his book. As is well known, astrology is still commonly practised in India, and anyone familiar with the methods of the East will readily believe that the native astrologer has preserved practically unchanged the routine which has been handed down by oral tradition from the earliest times. But, unlike the Westerners, who base all their divisions of the heavens on the circle, the Indian astrologer still bases his on the subdivision and bordering of the square, and, moreover, on successive division by two, which the study of the Ahmes papyrus of 1700 B.C. suggests as the primitive form of division.

Mr. Menon explains, in a very ingenious and, indeed, convincing argument, how this method leads, in a most direct and simple manner, to the numbers 4, 12, 28, 60, and others, which perpetually recur in all the ancient systems, but which have, until now, been persistently ascribed to a correspondence with certain astronomical

periods, although it has long been recognized that the correspondence is approximate only and that the divergence could not have escaped detection even by primitive observers. It now appears, if Mr. Menon is right, that these numbers originate in a mathematical, not an astronomical, necessity, and that they were used to build up a geometrical framework into which the astronomical phenomena were fitted. That some of them happened, curiously enough, to fit fairly closely, may well have been the cause of superstitious wonder, and possibly the justification of the well-known phrase, ascribed to Pythagoras, that "numbers rule the Universe."

Mr. Menon, in the pages which follow, has traced the consequences of this hypothesis, and has succeeded in reconstructing a "square" or "rectangular" cosmology, in which the pyramid replaces the bell as the vault of heaven. This cosmology seems to have been common to ancient Egypt, China, Vedic India, and Chaldea.

Much, of course, remains to be done before such a theory could be regarded as established, but Mr. Menon can claim to have set up a signpost which may well point to the unification, or at least the better co-ordination, of our knowledge of man's earliest attempts to form a coherent picture of the Universe.

Withal, it is a fascinating story he has to tell, one such as few young men of his age have the opportunity of unfolding in their maiden effort. With this I leave him confidently in the hands of the reader.

L. N. G. FILON

UNIVERSITY COLLEGE, LONDON
December 1931

PREFACE

"It has been accounted a fact by many historians in all ages," writes T. W. Kingsmill, President of the Royal Asiatic Society (North China Branch, 1907), "that important historical secrets lay hidden behind the Zodiacs which have divided between them the suffrages of civilized humanity, and that if we could discover the true origin of one or the other, we should go a long way towards ascertaining the conditions and locality of our earliest civilization." The present work seeks to clear up some of these secrets by means of a new treatment of *the problem of the so-called* Lunar Zodiac, which is known to the Hindus as the *Nakṣhatras.* A clue to the solution of this problem, that suggested itself to the author towards the end of the year 1927, was soon found to have an intimate relation to the more general topic of early cosmology; these and various other problems (like the origin of the sexagesimal system) which were shrouded in mystery, and which were not hitherto suspected of having any relation to one another, presently appeared to be but diverse aspects of a single mathematical scheme of conceiving the world.

The main theory regarding that conception is outlined in Chapter II, in which I have endeavoured to take the reader through the various stages by which I arrived at the conclusions. The general scope of the theory will be understood from the concluding section of that chapter. In the subsequent chapters it is sought to adduce evi-

dence in support of the theory, and to elaborate it in greater detail, as in the chapter on "The Meru Cosmology"; incidentally a few astronomical and other notions are explained, such as the original nature of the *Nakshatras*, or the identification of *Prajāpati* with the year, the Universe, the Altar, and the Sacrifices. The chapters also contain an explanation of the connection between (1) the ancients' conception of the Universe; (2) the square architecture of their Temples, Pyramids, Ziggurats, Altars, etc.; (3) the employment of symbols like the Cross and the Swastika in their art; and (4) their religious rites and ceremonies. Finally, the whole picture is reconstructed in the *Résumé* that forms the last chapter.

Though a large amount of material was available in confirmation of the above views, the limitations of time and space at my disposal have forced me to confine myself to the most salient facts. I trust that these may afford sufficient evidence in favour of the theory which bids fair to serve as a key to the clear understanding of many problems relating to ancient times.

It would be almost impossible for me to thank sufficiently all those who have assisted me in the production of this work. Professor L. N. G. Filon has been responsible for a large share of the result. Besides encouraging me, day in and day out, to continue these investigations, and affording me valuable help by way of criticism, guidance, revision, etc., he has been kind enough to write a Foreword. I can truly say that, but for the keen interest that he has taken all along in this theory, it might perhaps never have seen the light of day. Professor A. Wolf has

been equally ready with encouragement and assistance, especially in the arduous task of revising and editing the text for the press and making the necessary arrangements for its publication. Mr. A. Armitage, of University College, has also taken great trouble with the revision of the book. The University of London has aided its publication by a grant from the Publication Fund. I take this opportunity to express my deep sense of obligation to each and all of them, and to the several friends and well-wishers who have extended to me their never-failing sympathy and encouragement in the pursuit of my task.

C. P. S. MENON

"COCHIN HOUSE," COIMBATORE

December 1931

CONTENTS

ABBREVIATIONS

A.V.	Atharva Veda.
B.O.R.	Babylonian and Oriental Record.
E.R.E.	Encyclopædia of Religion and Ethics.
Ezek.	Ezekiel.
Ind. Ant.	Indian Antiquary.
Is.	Isaiah.
J.A.O.S.	Journal of the American Oriental Society.
J.A.S.B.	Journal of the Asiatic Society of Bengal.
J.R.A.S.	Journal of the Royal Asiatic Society.
M.N.R.A.S.	Monthly Notices of the Royal Astronomical Society.
Ps.	Psalms.
P.S.B.A.	Proceedings of the Society of Biblical Archæology.
Sa. Bra.	Śatapatha Brāhmaṇa
Sam.	Samuel.
S.B.E.	Sacred Books of the East (ed. Max Müller).
Z.D.M.G.	Zeitschrift der Deutschen Morgenländischen Gesellschaft.

EARLY ASTRONOMY AND COSMOLOGY

EARLY ASTRONOMY AND COSMOLOGY

CHAPTER I

INTRODUCTORY SURVEY

(A) THE ANCIENT SYSTEMS OF THE WORLD

§ 1. Looking Back

The same spirit of quest that urges us forward in the pursuit of fresh knowledge induces us continually to pause and look back towards our starting-point, and, when this has been lost sight of, to speculate about the origins of the Universe and the original conceptions of it. The Babylonian *Epic of Creation*, the Egyptian *Book of the Dead*, the Book of Genesis of the Old Testament, the *Purāṇas* of the Hindus, and other similar works extant are all found to contain such speculative accounts of the origin of the World. For the present generation, imbued with the doctrine of Evolution, attempts to trace the source of the stream of civilization have a peculiar fascination; especially inquiries regarding early cosmology, which naturally accompanied the formation of a system of abstract thought, and constituted a critical epoch in the progress of our culture. Yet, hitherto, we have had no adequate aids to a clear grasp of the primeval idea of the Cosmos. A few scraps of information have afforded us a glimpse into the past, but nothing conclusive and definite. There was first the vague belief in an early scheme

centring round a vault-shaped sky resting on the terrestrial disc surrounded by an ocean; further facts brought within our ken have forced us to grant the possibility of an at least equally early scheme differing from this; and the general tendency has been to conclude that the cosmology of the ancient countries formed two divergent systems which combined later into a novel and complicated system.[1]

§ 2. Early Greece

One of the first scientific systems of the World is presented in the Pythagorean set of spheres arranged in a harmonious order. Cruder, and perhaps earlier, concepts are found in Homer and Hesiod. The former describes the Heavens as a solid vault covering the earth like a huge bell; the earth was a flat circular disc surrounded by the mighty river Okeanos which started north of the pillars of Heracles, and flowed through the East, South and West, back to the North. Earth and Heaven were separated by a region of Æther; the sun, moon, and stars rose in the East from a gulf of Okeanos, moved beneath the bell-shaped Heaven, and plunged again into Okeanos in the West. Hesiod conceived the Earth as a plane dividing the Universe into two hemispheres. As much below the earth as the heavens were above was the mountain Tartarus, to which the Titans were chained; below the earth and above Tartarus was the abode of the dead.

[1] Cf. *E.R.E.*, Article "Cosmogony and Cosmology," for a concise account of such developments.

Many of the star-groups were known to the early Greeks and were, for a long time, regarded as due to their imagination and inventive genius. These are described in Aratus' *Phaenomena*[1], and are believed to be Homeric.

§ 3. The Old Testament

The Biblical allusions can be gathered together so as to give us some idea of the ancient Hebrew conceptions, though they show many incongruities. The heavens are referred to as a solid firmament, "strong as a molten mirror."[2] The angels, the hosts, the sun, moon, and stars move in this heaven; while above the heavens are the "upper waters."[3] Below the earth is the "Great Deep" from which the fountains spring. In other passages, however, the subterranean region is called Sheol, "the land of darkness and the shadow of death."[4] Similar variations occur in the descriptions of the supports of the earth:[5] now we are told that God "spread out the earth upon the waters,"[6] then that He "stretched out the north over empty space, and hangeth the earth upon nothing,"[7] and again the earth is stated to be resting on "pillars" or "foundations."[8] The constellations are called the "hosts of heaven." The ecliptic constellations are supposed by some to be intended by the *Mazzāroth* or *Mazzāloth*. Many of the star-groups must have been known by their names: "He telleth the number of the stars, He giveth them all their names." The Pleiades, Orion, and the Bear

[1] Supposed to be a versification of Eudoxus' book of that name.
[2] Job xxxvii. 18.
[3] Ps. cxlviii.
[4] Job x. 21.
[5] Ezek. xxvi. 20; xxxii, 23, etc.
[6] Ps. cxxxvi. 6.
[7] Job xxvi. 7.
[8] 1 Sam. ii. 8; Job ix. 6.

("Arcturus with his sons") are mentioned together in a single passage.[1]

§ 4. BABYLONIA[2]

The cosmological notions of the Greeks and the Bible are mostly found to be Babylonian in origin. The "Water-cosmogony" is supposed to have originated at Eridu, the primitive seaport of the country, situated on the shores of the Persian Gulf; the Babylonians believed the earth to have arisen from water, probably because constant deposits of silt from sea-water appeared as though land were "growing" out of the sea; and their natural environment led them to imagine that the earth was encircled by *Apsu*, the "Great Deep," or ocean-stream, beyond which "the sun-god pastured his cattle." On the other hand, at Nippur, another centre of early civilization, but situated inland in northern Babylonia, the world was built on stabler foundations than water: it was conceived as a huge mountain, and gods lived on its top. The totality of Babylonian cosmology is regarded as a compound of these two systems. The later scheme would represent the earth and the solid vault of the heavens as supported by the "Deep"; above the vault were the "upper waters," and above them the "sun-illuminated house" from which the sun emerged every morning through a door in the east, and into which it entered every evening through a door in the west. The sun appears

[1] Job xxxviii. 31, 32.

[2] Jensen: *Die Kosmologie der Babylonier*, pp. 235–8; see also Sayce: *Religions of Ancient Egypt and Babylonia*; and Maspero: *Dawn of Civilization*.

to have been regarded as moving during the day—as the moon and the stars by night—along paths marked on the fixed vault of heaven. From the heaven to the earth extended the waters of the eastern and the western oceans, which, like the southern ocean, were parts of the great *Apsu* that supported the world. The earth was a great hollow mountain, divided into four quadrants, though perhaps originally divided into seven zones inside each other. Other mountains also appear, such as the bright mountain or mountain of sunrise in the east, and the dark mountain, or mountain of sunset in the west. The northern part of the earth was unknown and mysterious. Inside the crust of the earth, and above the hollow interior, was the abode of the dead, whose entrance was in the west.

The so-called Homeric constellations are now admitted to be derived from Babylonian originals. Many of these are found on the Babylonian boundary-stones, cylinders, seals, etc., of *c.* 1200 B.C.; and probably they were known as early as 3500 B.C. They were thought of as the "hosts of heaven," led by a Prince, *Ku*—a name applied to Aries, and earlier to Taurus, when these occupied the position of the vernal equinox, and led the zodiacal constellations from the beginning of the year.[1]

§ 5. INDIA

From what we can gather from the stray descriptions of the several parts of the world in the *Ṛig-Veda* and other Vedic texts, the Universe seems to have been

[1] Cf. Allen: *Star-names and their Meanings*; Brown: *Primitive Constellations*; Jensen: *op. cit.*; Maspero: *op. cit.*

regarded in the Vedic age[1] as consisting of "the two halves," Heaven and Earth; these are described in one place as "the two great bowls turned towards each other." Though the earth is here given a hemispherical shape, it seems to have been usually conceived as flat,[2] but it was not necessarily circular.[3] The heaven, as in Babylonia and the Old Testament, is a solid vault to which the stars are fixed; though sometimes, and here bearing a further resemblance to the Babylonian and Biblical ideas, there is a firmament above the sky, where abide the gods and light. There are again intermediate spaces of Æther between Heaven and Earth.

A marked deviation from these notions is offered by the cosmology of the *Sūryaprajñapti*, a Jaina treatise on astronomy, and the Hindu *Purāṇas* or mythology. The world is flat and made up of a number of concentric rings, alternately land and sea. The central island is our earth, the Isle of Jambu (*Jambu-dvīpa*), divided into four quarters, of which the southernmost is India. At the centre of the earth is a huge mountain, *Meru*, round which revolve the various celestial bodies in horizontal orbits at definite heights above the earth. The outermost sea is surrounded by a chain of mountains, *Lokālōka*, which forms the limit to which the rays of the sun extend; beyond it is a deserted ever-dark land. Above the earth are six world-strata (*Lokas*), and below it are the seven infernal regions; the whole is enclosed in the *Brahmāṇḍa* or Cosmic Egg.

1 Cf. Wallis: *Cosmology of the Ṛig-Veda.*
2 Broad (*Prithivī*), extended (*Uttānā*), and boundless (*Apārā*).
3 See Chapter III.

This primitive scheme was no doubt devised to explain the ever-increasing puzzles offered by the celestial phenomena. Thus *Meru* helped to explain—like the lofty northern part of the Earth in Babylonia—the disappearance of the sun during the night and of the moon and stars during the day, because these passed round the mountain. This was improved upon in the *Sūryaprajñapti* by adding that the phenomena of rising and setting of these bodies depended on their becoming visible within certain distances. The daily change of altitude of the sun was explained as an *appearance* due to the decrease of distance from the observer, the sun keeping the same height above the earth. The annual change of altitude (obliquity of the ecliptic) was similarly the result of the variations in the dimensions of the daily orbit of the sun. At summer solstice, the sun moved along the smallest orbit, which was nearest to man, and the orbit continued to grow wider, and the sun to recede, during the course of the half-year till the winter solstice, when the orbit was the largest, and the sun was farthest from man, so that it appeared to have the least altitude. This process was reversed during the subsequent half of the year.

Both these schemes may have contributed towards the scheme of the later Treatises on Astronomy, the *Siddhāntas.* The earth is a sphere at rest in the centre of a spherical Universe; and *Meru* becomes the celestial Pole (the centre of motion of the heavenly bodies) as well as the pole of the earth.[1]

[1] See Chapter IV.

§ 6. China

Of ancient Chinese cosmology, as such, very little is known that could be definitely attributed to pre-Buddhistic times. Chinese Taoism derived the four seasons from the conjunction of the male and female principles *Yang* and *Yin*; the four seasons produced the eight *Kua* or phenomena of nature; these eight phenomena are the ingredients that constitute the Universe. These gave rise to the 64 Hexagrams of the *Yi King* or *Book of Changes*, on which later Chinese cosmology is based, but which, according to Legge,[1] originally had no connection at all with philosophy. Schlegel, in his *Uranographie Chinoise*, goes on to describe the several star-groups and mansions, without telling us what exactly was the form of the Universe as conceived by the ancient Chinese; it is perhaps assumed that the "Dome of heaven" or the "starry sphere" were the only possible shapes for the heavens.

One Chinese book, the *Tcheou-pei*,[2] gives a description of celestial motion comparable to that of the *Purāṇas* and the *Sūryaprajñapti* in India rather than to the Babylonian and the Vedic "vault of the heavens."

Such, in short, is the present view of the cosmologies of the ancient nations at the dawn of civilization. They exhibit many similar features that cannot but arouse the interest of the investigator of early relations between the branches of the human race. Some of these features, like the vault of heaven, are obviously the result of observations that could have been made independently by

[1] Also see *E.R.E.*, article "Cosmogony"—China.

[2] See below, Chapter IV.

any of these peoples. But there are others, like the Water-Cosmology or the Mountain-Cosmology, which are more likely to have been conceived by one community and transplanted to distant lands, whether by migrations or by communication. Whereas the Water-Cosmology was explained by reference to the geography of certain localities, like the shores of the Persian Gulf or the banks of the Nile, the Mountain-Cosmologies of the different countries do not seem to have been explained with similar cogency.

Though no serious attempt has been made to reduce the different cosmological accounts to one original system, there are one or two details common to the different nations, and their origin has been the subject of repeated discussions.

(B) THEORIES OF THE ORIGIN OF THE DIVISIONS OF THE ZODIAC

§ 7. THE SIGNS OF THE ZODIAC

The twelve zodiacal signs, Aries, Taurus . . . Pisces, were for a long time regarded as the invention of the Greeks with whom Science originated.[1] But it was also known that the invention was attributed by some classical authors to the Egyptians, and by some to the Babylonians. They are now generally believed to have arisen in the Euphratean valley, because of the appearance of the stellar pictures of the Bull, the Scorpion, etc.,

[1] So much so that the mention of one of the names of these signs in a Hindu book was adjudged a sufficiently weighty reason to allot the book to the post-Greek period.

on boundary-stones discovered there. It is not even suspected that these constellation-*figures* and the twelve *divisions* might perhaps have had no connection originally.

Following this theory of the formation of the constellations Lockyer[1] tries to trace their origin from *three* of the stars worshipped in ancient Egypt. In pyramid times there were *six* Gods—*Isis, Hathor, Nephthys, Ptah, Selkit,* and *Sokhit,* of whom "the first two and the last two undoubtedly symbolized stars," whose rising governed the orientation of some of the temples. There is again the theory that the divisions were possibly only six to start with—Taurus, Cancer, Virgo, Scorpio, Capricornus, and Pisces—and that these were later divided into twelve, because of the number of full moons in the year. According to Servius (A.D. 440) there were only 11 signs for a long time, till the "Scorpion and its Claws" was broken into two separate parts. A reconciliation of some of these views is aimed at in the supposition that the Babylonian signs were introduced into Greece by Cleostratos of Tenedos (*c.* 500 B.C.), and that, these zodiacal constellations being of unequal extent, Hipparchus more scientifically divided the ecliptic into twelve equal spaces of 30 degrees each—the twelve signs still in almanac use.[2]

§ 8. The Lunar Zodiac

The ancient nations, like the Hindus, the Chinese, the Arabs, the Persians, the Sogdians and Khorasmians, and

[1] Cf. Lockyer, Sir J. N.: "Early Asterisms"—*Nature*, September 7, 1893, pp. 438–40.

[2] Allen: *Star-names*, p. 6.

the Copts, used a system of divisions of the ecliptic into 28 (or 27) parts, unknown to the Greeks. These were called "Lunar Mansions," primarily because of their supposed connection with the moon. The Arabs called them *Manāzil* or "alighting stations," i.e. of the Moon, where he rested every day throughout his monthly travels; the Chinese called them the *Sieou* or mansions; the Hindus called them the *Nakshatras*, and referred to them as the "wives of the moon." Their number was usually 27, and often 28. This is nowadays called the "Lunar Zodiac," as distinguished from the "Solar Zodiac" of 12 signs, because of the relation of the two zodiacs to the periods of the moon and the sun respectively.

More than one heated controversy has raged round the question of the origin of this system, which has been claimed for one nation or another, usually by scholars interested in the literature of that particular nation. Thus Max Müller held that it originated in India; Biot and the Sinologists, in China; Sédillot and others, in Arabia; Hommel, Brown, and other Assyriologists, in Babylonia. Of more permanent interest to us are the different theories that emerged during these controversies regarding the original nature and the process of development of this system, rather than its place of origin.

A common explanation of the origin of the *Nakshatras* is briefly this. An unknown astronomer at some time in the past observed the moon's path among the stars, and picked out 27 of the more prominent stars and star-groups with which the moon came in conjunction every day, or, rather, every night; at some later time, with

improved knowledge of the moon's period as $27\frac{1}{3}$ days, an additional *Nakshatra*, *Abhijit*, was inserted in the series, and assigned the extent of $\frac{1}{3}$ day.

This theory would point to India as the natural home of the *Nakshatras*, since all these stages can be traced in her literature, sacred and profane. But there are a number of difficulties in the way of accepting it. (1) The system based on the path of the moon could not have been considered sufficiently permanent for the purpose of measuring time, and of referring to the position of the stars, considering that the moon must have been soon found to deviate from the path first observed and from the "stages" marked by the constellations, because of the variations of her velocity, the incommensurability of her period, and the motion of her nodes and apses. (2) The number 28 is not necessarily a later number as it appears in one of the earliest literary works, not far from that which first mentions the number 27.[1] (3) There is the express reference of Bhāskara (A.D. 900) to the fact—to which Brahmagupta also alludes—that the series of 28 *Nakshatras* was used solely when greater accuracy was needed, and that 27 equal *Nakshatras* sufficed for ordinary purposes. So that it would appear that the two series were used side by side. (4) In the *Sūrya-siddhānta* and other works a few *Nakshatras* are described as situated in defined portions of adjacent *Nakshatras*; this Whitney[2] explained as due to the conception of a series of 28 *Nakshatras* or star-groups which could be referred, like

[1] See Chapter III.

[2] Cf. *J.A.O.S.*, Vol. VI: "On the Sūrya-siddhānta."

the sun, moon, and the planets, to a series of 27 divisions, also called the *Nakshatras*; however, he imagined these to have originated from a series of ecliptic constellations which marked out crudely the divisions of the ecliptic.[1]

A novel theory was put forward by Biot,[2] who claimed that the system had originally no connection at all with the moon or her revolution among the stars, but was only a series of single stars near the celestial equator of 2350 B.C., selected by the Chinese astronomers of the period as points of reference in observing the intervals and the instants of meridian transit of the heavenly bodies. They were originally 24 stars selected from considerations of brightness, proximity to the celestial equator, and possession of special relations to the declination circles of nineteen circumpolar stars known to the Chinese from time immemorial. The system was perfected in 1100 B.C. by Cheu-Kong by the addition of four other stars. "This singular institution," Biot held, "has its root and its explanation in the practical methods of ancient Chinese astronomy, whence the Hindus derived it, altering its character in order to employ it in astrological speculations . . ." and "seizing upon the chance coincidence of its number of divisions with the days of the moon's sidereal revolution to bring it into special relations with that planet."

Yet another theory was favoured by Hommel,[3] who

[1] Cf. Whitney: *J.A.O.S.*, Vol. VIII: "On the Views of Biot and Weber," etc.

[2] In a series of articles in the *Journal des Savants*, 1840, reprinted as *Recherches sur l'Ancienne Astronomie Chinoise*.

[3] *Z.D.M.G.*, Vol. XLV., p. 592 *et seq.*

tried to reduce the 27 Hindu *Nakshatras*, the 28 Arabic *Manāzil*, and the 33 Babylonian constellations of Epping and Strassmaier,[1] to a series of 24 groups. He meant to show that the series were all derivable from the 12 divisions of the ecliptic, by bifurcation of each division, and a later addition of 3 or 4 groups; in the case of the Babylonians, the 28 groups so formed were increased by the formation of 8 pairs of twins, and out of these three constellations were assumed to be missing, so as to leave the 33 on the tablet. But this theory was easily shown to be rather arbitrary.[2]

§ 9. (c) THE SEXAGESIMAL SYSTEM

One other isolated detail deserves consideration before concluding this chapter, viz. the sexagesimal notation known to have played so prominent a part in the computations of the ancient nations, especially the Babylonians. Speculation has been rife trying to explain why the number 60 was chosen for the special honour of being the radix of their system. Primitive peoples used the numbers 5, 10, or 20 as bases of their systems of counting, since these were the natural limits up to which they could count on one hand, or both hands, or the hands and feet. An explanation along the same lines will be that *60* is the least number which contains all the numbers up to 5 as factors. A second, slightly different, explanation is that it is the product of the consecutive numbers $3 \times 4 \times 5$.[3]

[1] See below: Chapter VI.

[2] Cf. Thibaut: "On the Babylonian Origin of the Lunar Zodiac," *J.A.S.B.*, Vol. LXIII.

[3] David Eugene Smith considers it "probable that 60 was chosen

There is also the more mathematical theory that the number represents the *degrees* in the angle of an equilateral triangle: the circle was divided into 360 degrees, corresponding to the 360 days reckoned in a year by the ancient nations; when the radius of the circle was set off as a chord of the circle, and the ends of the chord were joined to the centre, the angle at the centre was found to contain 60 parts. This theory was seriously questioned by Sayce and Bosanquet,[1] who stated that the divisions of the circle actually found in certain Babylonian tablets which they had examined were into 8, 12, 120, 240, and 480 parts, never into 360 degrees; that the division of the circle into 360 parts was an assumption due to Achilles Tatius, and that such division, as practised by Ptolemy, and in modern times, was an outgrowth, rather than the source, of the sexagesimal method.

The explanation of this system, like the origin of the divisions of the Zodiac and the primitive system responsible for the cosmological beliefs sketched above, awaits a radical enquiry.

because of its integral divisors 2, 3, 4, 5, 6, 10, 12, 15, 20, and 30, thus rendering work with its fractional parts very simple." —*History of Mathematics*, Vol. I, p. 41.

[1] *M.N.R.A.S.*, Vol. XL, No. 3 (1880), p. 108 *et seq*.

CHAPTER II

RECTANGULAR ENCLOSURES

§ 1. The Original Division of the Zodiac

After all the discussions noticed in the last chapter the question still remains, how did the Signs or Lunar Mansions arise? Were they formed by independent observations of the full moons in a year, and of the daily stages of the moon during her sidereal revolution, or was

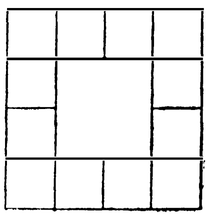


FIG. I

there a more permanent scheme underlying any such observations? Again, was either of these zodiacs derived from another, possibly earlier, one? Perhaps the two zodiacs, the solar and lunar, had nothing to do with these luminaries to start with.

I have observed the astrologer in India trying to represent the positions of the heavenly bodies on the ground as a preliminary to his calculations and predictions. He first draws a square, and divides each side into four. The points of division near the corners are joined by lines parallel to the sides; from the middle points of the sides, perpendiculars are drawn to these parallels. Or, what

comes to the same thing, he joins all the points of division by lines parallel to the sides, and rubs off the four squares in the centre (Fig. 1). Thus he gets 12 small squares round the sides which he calls "houses"; these houses correspond to the 12 signs of the Zodiac, and to one of these he assigns one or more celestial bodies according to their longitudes. For instance, if the longitude of Jupiter is 40 degrees, it is in the "Bull," and he places in the "second house" some object representing Jupiter.

Now supposing that the primitive astrologer had felt the need of representing the positions of the celestial

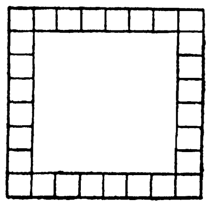


FIG. 2

bodies more accurately, what would he have done? If he wanted smaller divisions of the Zodiac, he would naturally divide each side of the square *again*, i.e. into 8 parts, and join the points as before, and so get a number of small squares round the sides (Fig. 2). The number of squares round the edge is the difference between the total number of small squares contained in the big square and the number of squares that may be supposed to be rubbed off, i.e. $8^2 - 6^2 = 28$. These divisions were used as a finer scale, and, as their number was near to the number of days in the sidereal period of the moon, they were suited for association with the moon, each square being called

a lunar mansion. This scale, being originally unconnected with the moon and her variable path, could itself form a *permanent* framework. Again, it is derived immediately from the scale of 12 divisions, without any arbitrary addition of 4 stars, as is the case with Hommel's theory.

I was myself inclined to treat this derivation of the Lunar Mansions as an hypothesis with no more support than the numerous others claiming to explain their origin, but I was startled out of my indifference to the hypothesis by the discovery that the process of division would yield the important number 60. If the primitive astrologer wanted still smaller divisions, he would proceed to divide each side *again*, i.e. into 16 parts, and join as before: the number of squares left round the edge is now $16^2 - 14^2 = 60$. The system of 60 divisions was one of the finest scales known to the ancients, and we have here at last an explanation of the origin of the sexagesimal system, which is very simple and more rational than the usual theories noticed in the last chapter.

If he had carried on this division a step farther, he would have 32 divisions on each side, giving $32^2 - 30^2 = 124$ squares (or 4×32 *minus* the 4 corners that are repeated). A scale of 124 divisions was known to the Indians of the Vedic Age.[1] This must appear a very peculiar scale to have been employed by the ancients, as it possesses none of the virtues—such as having 3, 5, etc., as factors, or any simple relation to the 360 degrees of the circle—attributed to the base of the sexagesimal system.

[1] See below, Chapter III.

But it is seen to be a natural step in the division of the square enclosure.

Repetitions of this process of dividing could be depended upon to yield finer and finer scales, in accordance with their requirements. These divisions form a series whose general term, $t_n = n^2 - (n-2)^2 = 4 \times (n-1)$ where $n = 2, 2^2, 2^3, \ldots$. The next stages will be 252, 508, etc., of which the first could again be found in India, and the second is one of the sacred numbers of the Hindus.

Going back one stage from the 12 mansions commonly employed by the astrologer, we get 4 as the number of

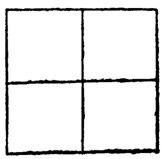


FIG. 3

the series corresponding to $n = 2$, obviously the very first stage in the division of space (Fig. 3). The "Four Cardinal Points" or the "Four Directions" were known to the earliest nations, and are found in use among primitive tribes such as those of California.

From such a figure, then, by successive operations of dividing, they obtained the various scales of 12, 28, 60 . . . divisions. *Division* means partition into two—a number which primitive minds found the most convenient to manipulate. The Egyptian mathematicians are known to have worked by multiplication and division by *two*; successive *halving* is used by workmen in England even to-day. The process of halving was probably the

first method of *graduation* employed to get finer divisions.

§ 2. An Alternative Method: The Method of Borders

A slight insight into this ancient habit of employing square scales cannot fail to direct the attention of anyone brought up in a Hindu environment to the curious fact that all his sacred institutions are bound up with the square shape. The Hindu temples are all based on *square* plans, which include a number of corridors round the *sanctum sanctorum* at the centre; the sacred tanks

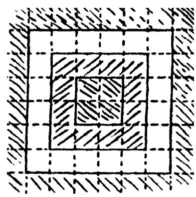


FIG. 4

in front of these temples are square-shaped, and the steps built round these tanks for descending to the surface of the water are also built on the same plan. The plans are the same as though the square scales were put one inside another, the unit square being of the same size in all the scales.

When we draw the figure (Fig. 4), we find that there are spaces left empty between the scales representing the numbers found in the previous section. These spaces must, on the same system, correspond to new numbers. The new series is 4, 12, 20, 28, 36, 44, 52, 60, 68, 76, . . . 100, whose *n*th term $t_n = (2n)^2 - (2n - 2)^2 = 4 \times (2n - 1)$

where *n* is any positive integer. Many of these numbers are known to have been regarded as fundamental, some of them being used as bases of cycles, e.g. a system of 36 divisions was known to the Babylonians[1] and the Egyptians as the Decans, while the numbers 100 and 108 were sacred numbers of the Hindus; 76 was the number of years in the Kalippic cycle, and 68 might have prompted the use of 67 as the number of sidereal months in the 5-year cycle of the Vedic Āryans, in just the same way as the number 28 gave place to 27 as the number of lunar mansions.[2] It is quite possible that these *cycles* and the *circuits* of the Hindu temples were of kindred origin.

Fig. 4 could be obtained either by drawing the *borders* round the central square, or by drawing the enclosures on a network of squares (like squared paper) already prepared. Such figures were familiar to the ancients, and have come down to us on their works of art and other works.[3] This fact, as well as the obvious connection of these "borders" with the "cycles" of the ancients, has persuaded me to include this "method of borders" as an alternative to the method of division (see previous section); but the latter must be admitted to be more direct and characteristic as a method of graduation.

[1] See below, Chapter VI. 20 was the radix of one system of arithmetical notation that prevailed in many parts of the ancient world, especially among some primitive communities; it still survives in the British score, as in "three score and ten." The duodecimal system appears in the distinctive British measure: 12 inches = 1 foot. A part of the series is found as the multiples in currency: 1 sovereign = 20s.; 1s. = 12d.; 1d. = 4 farthings.
[2] See below, Chapter III.
[3] See Chapter VI, 3, 5, 6, and Chapter VIII.

§ 3. The Devices of the Computer

The methods sketched above are precisely what a computer would have resorted to in antiquity. The ancient astrologer—who was more of a computer than an observer—took his observations from the "watchers of the skies," and made his calculations and predictions. For either of these duties he employed cycles which were known to him already, and in which he had complete faith. His belief in cycles induced him to employ the different "circuits"—such as those described in §§ 1 and 2—to represent the different cycles. Further, each square in a circuit or zone being *unity*, each zone represented the *number* of units in the cycle, so that an astronomical period could be represented by one or other of these scales, to whose number of units the period approximated. Thus the scale of 12 squares could be associated with the number 12, and with the astronomical periods of 1 day consisting of 12 double-hours, or 1 year consisting of 12 months, or Jupiter's period of 12 years. Very probably the astrologers' faith in these fundamental numbers helped them to *fix* these periods, small fractions being neglected as due to errors of observation: the period of Jupiter, for instance, and the number of lunar mansions may have been so fixed as 12 and 28 (or 27) exactly rather than approximately.[1]

Again, it seems very probable that the signs, the

[1] We are not very different, considering how we resort to simple integers in chemical formulæ and in many fundamental physical *Laws*, e.g. that of the Inverse Square ratio, though we realize that they are only approximate.

Nakshatras, etc., were originally mere divisions of the Zodiac rather than constellations. The constellations could have been chosen later to *specify* these various divisions. One manner in which the star-pictures could have arisen is also explicable on these lines. Let us recall the fact that the Indian astrologer is still used to representing the position of a celestial body by an *object*, usually one or more cowrie-shells, placed in one of the "houses" corresponding to the longitude of the body. The primitive astronomer might have similarly used different objects, like models, or pictures,[1] of the various animals known to him or else imagined, to represent the different divisions of the scale; later on, these were transferred to the skies, a number of prominent stars in or near a zodiacal division being imagined as the picture of an animal symbolizing that division.

These devices are consistent with the habits of a primitive civilization. The essence of civilization, as we understand the term, is a *system*, whether political, moral, religious, or cultural; and systematization is necessarily preceded by abstraction. One of the most important steps in the progress of our civilization was taken by the man who took the first leap across the gap that separates the *abstract* from the *concrete*. Our primitive computer uses concrete objects to denote something other than these objects: for him they have come to mean a certain *number*. The emergence of the Number-concept marked an important stage in the progress of Science. The computer goes farther still, and denotes a number

[1] See below, Chapter III.

parts of an interval, for instance, by *one* object or one set of objects placed in the appropriate place, like a particular square; this object was perhaps a small piece of stick or stalk, as used in China, or a small line drawn on the ground. Parallel to this development was the representation of other abstract ideas by concrete objects or lines drawn on the ground—thus giving rise to the ideograms and the hieroglyphs, believed to mark the beginning of writing. We have, therefore, struck upon the very fountain-head of civilization marked by the

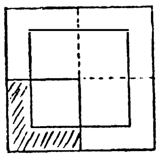


FIG. 5

symbolization of the *abstract* by concrete objects and pictures, and the consequent origination of writing, arithmetic, and astronomy.

§ 4. THE GNOMON

The borders or corridors described in § 2 bear an obvious affinity to the Pythagorean *gnomon*, inasmuch as either of them forms the difference of two squares, geometrical as well as arithmetical. According to Aristotle, Pythagoras regarded the gnomon as "the figure which, when added to a square, preserves the shape and makes up a larger square."[1] By this is usually meant the shaded portion of Fig. 5; but clearly the definition could apply to our

[1] Heath: *Greek Mathematics*, Vol. I, p. 18 *et seq.*

borders equally well. The shaded portion is only a quadrant of the closed border, which may be called the *complete gnomon*. According to the Pythagorean scheme of geometric numbers, the odd numbers formed the gnomons and were the gnomonic numbers: these are exactly one-fourth of the numbers of our series 4, 12, 20, 28, 36, . . . $4 \times (2n - 1)$, each of which is the number of unit squares in the different "complete gnomons." We have here, moreover, a fundamental connection between number and form, which Pythagoras and Plato insisted upon, forming a system, no worse, and slightly more far-reaching, than that attributed to Pythagoras. The Pythagorean doctrine must have been derived from the original and more symmetrical scheme.

It is again not difficult to imagine a squared plank with a number of such concentric borders marked on its surface, as having been employed as a *sun-dial*, either alone or with a staff in the centre to throw shadows on the scale. The last combination might have been originally used for the purpose of shadow-measurement, the length of the shadow being directly "read off" one of the borders or "gnomons." The facility with which these lengths could be "read off" the scale and easily "known" might have suggested the name "gnomon": and this name was extended to the numbers associated with the gnomon.[1] These arguments are of course applicable to an instrument in the shape of the Pythagorean (quadrant) gnomon,

[1] Cf. Philolaus' statements that "number makes all things knowable and mutually agreeing in the way characteristic of the gnomon," *also* of "making the *knowing* embrace the *known*, as the gnomon does the square." Cf. Heath: *loc cit.*

was really appropriate to the plank on which the gnomons were drawn, was, by a usual freak of popular imagination, misapplied to the stick which cast the shadow, and was therefore regarded as the more essential part of the instrument: it was still understood that the stick was used along with the plank. As time passed on, the unnecessary parts of the instrument were cut off: instead of the complete dial, only a quadrant was used; and it was also possible to dispense with the upright stick by holding the quadrant gnomon so that one edge was vertical and cast shadows on the other edge which served as a horizontal scale. Thus it would appear that this instrument, shaped like the Pythagorean gnomon, and supposed to be the original instrument of that name, may really have been derived by *abridgment* of the original dial.

This original plank is also found to be capable of being used as an astrolabe, by holding it in a suitable position.

[1] Heath: *loc cit.*; also see D. E. Smith: *History of Mathematics*, Vol. I, p. 69.

§ 5. Square-shaped Enclosures

If the divisions of the Zodiac were obtained by dividing the square drawn on the ground, it will be asked, were these only convenient diagrams, or were they to any extent intended to be representations of the heavens above?

It will be seen in some of the following chapters that the Zodiac itself was actually conceived as a square. The zodiacal divisions, therefore, were rather in the nature of a number of compartments or "mansions" into which the surrounding space was divided. The celestial equator was also probably regarded as similar. So also was the horizon, with different mansions in the different *directions* presided over by corresponding deities. The square shape of the horizon, taken together with the known fact that the earth was considered by the ancients to be flat, defines the shape of the earth as a flat square.

§ 6. Three Dimensions

The square shape of these enclosures inevitably leads us to inquire into the shape of the heavens and of the world in the same scheme. It could not have been the "dome" or the "sphere" described in the last chapter, since this shape accompanies a *circular* horizon. On the other hand, some idea of the surrounding space above the earth may be obtained by joining the zenith to the boundary of the horizon by means of straight lines: the solid so obtained is a *pyramid*. Here we have the explanation of the huge monuments built so carefully, and left behind, by the Egyptians and other ancient nations

all over the world. It is not only possible, but it seems even probable, that the pyramidal temples, where the images of the Celestial Beings were worshipped, were models of the shape of the heavens. In this cosmology the *Dead* inhabited other similar worlds—whether above or below the earth—and consequently the dead bodies were interred in tombs of the same shape, resembling Heaven or Hell. If they had originally thought of such an infernal region—forming a sort of reflection of the

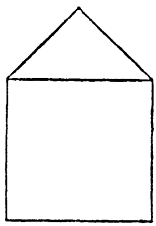


FIG. 6

Heavens, like the two bowls in the *Ṛig-Veda*—the Universe would be included in an Octahedron.

An alternative scheme is obtained if, instead of having *one* highest point above, they had imagined a flat ceiling, supported on pillars or high walls erected on all the four sides of the earth. In the latter case, they would have a cube as the shape of Heaven. Again, the space above the earth may be a cube, crowned by a pyramid forming the "Uppermost heavens," as distinguished from the "Intermediate space." The figure so formed (Fig. 6) is found to have been drawn by the Babylonians.

Again, the Earth itself may have been imagined as pyramidal, resembling the heavens above—an idea that will be found to be supported by certain calculations in

Hindu astronomy. There were several other solid objects —such as Mount *Meru* [1]—which conformed to this prevalent conception of pyramids, in harmony with the basic square in two dimensions.

§ 7. From Square to Circle

These squares that determined the primitive enclosures gradually evolved into circular shapes. The horizontal, equatorial, and ecliptic boundaries became great circles of the celestial sphere. The pyramidal heavens, developing on the same lines, gave rise to the "vault" of Heaven or the "dome" above us. The octahedral or cubical World, whether by "World" was meant the Universe or the Earth, was transformed into the spherical globe. The same path of development was taken by the square dial in turning into the circular astrolabe, which was in great vogue in medieval Europe. So also, we may imagine, was the evolution, in the field of architecture, of the Teutonic gable into the arch, and of the flat or pyramidal roofs into domes.

We must here meet a possible objection, that the square did not precede the circle logically or in respect of time; for the usual belief is that the square is a later conception than the circle, since the construction of a right angle involves the knowledge of drawing an arc of a circle. But such accurate constructions were unnecessary for the purposes of primitive man. Straight lines are easier to draw than circles; and the concept of a perpendicular line is tantamount to that of an equal inclination—or,

[1] See below, Chapter IV.

rather, of no biased inclination—to either direction, which is sufficiently simple to come within his purview. Moreover, the square shape was more suited than the circle for purposes of graduation, since the straight line could be divided more easily than a circle. As an instance of this earlier use of the square I may point out that all ancient architecture, like the temples of the Hindus, Babylonians, and Egyptians, was based on the square; circular buildings appear only later.

§ 8. Summary

Thus we have here one complete picture of the Universe, instead of the few dim marks, scattered and unconnected, and supposed to belong to the different localities in which they are found. This picture gradually faded out of the memory of the peoples during the course of the ages, and later interpreters only increased the confusion by construing the ancient cosmology in terms of the circular shape current in their own times, and thus leaving us very few clues for its elucidation. The predominant square shape provided the primitive peoples with a convenient way of representing the different cycles, whether the cycles meant the enclosures in *Space* that were repeatedly traversed by the celestial bodies, or the number of units of *Time* taken by the bodies in traversing such an enclosure. As applied to space, it enabled them to conceive of the different enclosures, as well as the earth, the heaven, and the universe, as built on a square plan. The representation of the units of time in the cycles was achieved by the device of dividing the edges of the square

and joining the divisions so as to obtain a number of small squares round the edges, and assuming each square to be equivalent to a unit. Thus the scales could be used to represent a fundamental number. These fundamental numbers and shapes were the flesh and bone of their Universe—in a more concrete and living sense than the Pythagorean doctrine of "Number" as the primary "matter" of the Universe. The square shape was again made use of in the construction of their instruments and buildings. Further, the primitive methods were associated with the primitive symbolism that eventually gave rise to the beginnings of writing, to arithmetical notations, constellation-signs, and possibly to much of the later philosophy of some of the ancient countries. The theory, therefore, explains the origins of several important systems like the signs of the Zodiac, the Lunar Mansions, and the sexagesimal notation; it indicates the origin of the gnomon and the astrolable; it explains the *raison d'être* of the Pyramids and other edifices; and, above all, it presents a *unified* conception of the Universe as understood by early man at the dawn of civilization.

The *evidence* for the theory that I have so far been able to find is set forth in the following chapters. I have tried to adduce evidence in support of the ancient use of the fundamental square shape, of the basic numbers, and of the mode of division sketched above. The evidence may be either (*a*) direct, or (*b*) indirect; i.e. (*a*) statements or references, explicit or implicit, in ancient records, and (*b*) the solution of certain outstanding problems by applying the theory.

CHAPTER III

HINDU ASTRONOMY: THE ZODIACAL DIVISIONS AND THE SQUARE FORM IN THE SACRIFICIAL ERA

§ 1. The Year-Cycle and its Divisions

As a preliminary to the testimony regarding the square shape of the Universe offered by the Vedic age, I shall deal briefly with a few of the habits and conceptions of the Vedic Āryans which bear also on the original *nature* of the Zodiac. These ancients, who worshipped Nature and especially the stellar deities, made a habit of offering sacrifices at the end of every year, or at the solstices and equinoxes, or other astronomical epochs. These sacrifices appear to be symbolic of the end (or sacrifice) of one cycle, like the year or a season, and the beginning of a new one; the commencement of a new year at the vernal equinox, for instance, was regarded as a renewal of Life, and a cosmic epoch. Eggeling observes that "Time itself, in the shape of its unit, the Year, takes its part in the primeval sacrifice";[1] texts state that "the sun is the cause of Time, the year is the visible form of it";[2] there are numerous statements, like "the year is sacrifice," which tend towards the same conclusion. Several other entities like the fire-altar, the universe, and *Prajāpati* are all identified with one another and with the Year and the Sacrifice; we find that all these form a consistently

[1] Cf. *S.B.E.*, 43, p. xv.

[2] *S.B.E.*, 15, p. 316.

interwoven system, on the hypothesis of the astronomical symbolism of the Sacrifice, and on no other.

The reference to the year as the "visible" form of Time, and other kindred references like "The Year is Space"[1] or "is the firmament"[2] or "is the world of heaven"[3] appear to me to apply to the Year-Cycle or the rudimentary Zodiac, which, being the path traversed in the heavens by the Sun-god in one year, formed the connecting link between Time and Space. The Vedic *Prajāpati* has always been an obscure and complicated concept; but it is easily understood on this system. *Prajāpati* (= Lord of Creatures) was perhaps the Lord of the Creatures of the Zodiac (cf. ζῷον = animal = *prajā*); he was therefore capable of representing the Year. Further, there were a number of these *Prajāpatis*, like *Indra, Dakṣa, Kaśyapa,* etc. Brennand, in his *Hindu Astronomy,* shows how *Dakṣa* was only a personification of the Ecliptic and the Year; *Indra* and others were the *Ādityas* (see below, § 2) connected with the divisions of the ecliptic. *Dakṣa* is regarded sometimes as the parent, and sometimes as the offspring of *Aditi*; this is understandable, if *Aditi* ("endless") represented the "Enclosure";[4] for *Dakṣa* was a *Prajāpati* situated at one point of the ecliptic, and capable of representing the particular zodiacal *division* including the point, or the whole Zodiac. The other deities were also similarly situated at different parts of the ecliptic, and generally

[1] *S.B.E.*, 43, p. 62. [2] *Ibid*, p. 65. [3] *Ibid.*, p. 100.

[4] *Aditi* was also described as the Goddess Earth; perhaps it meant the Horizon, the boundary of the earth, as also the ecliptic.

reigned over a division; one or other of them was designated the special lord of the Zodiac, the supreme *Prajāpati*, according as his location formed the important part of the ecliptic, because of coincidence with a solstice or equinox, or for other such reasons. By the same process of extension of jurisdiction, *Prajāpati* could be identified with the Universe.

Thus, instead of merely possessing a Solar Zodiac and a Lunar Zodiac, the Vedic Āryans regarded the Year-Cycle, in its dual aspect of Time and Space, as representing the Universe, and capable of division into a number of parts which similarly represented time-intervals as well as spatial portions; though these spatial portions were pictured like animals, the *divisions* formed the essential part.

§ 2. The 12-fold Division

Even the Solar Zodiac and the Lunar Zodiac could be shown to have been based on a system of *divisions*, corresponding to the basic number 12 (or 28) to which an astronomical period was related; the actual filling in of the pictures of the "animals" followed this system of divisions.

Only the ignorant assert that there was no Solar Zodiac, but only the Lunar Mansions, in India till the Greeks introduced the signs into the country. The earliest literary work, the *Ṛig-Veda*, describes it: "the twelve-spoked wheel revolves round the heavens, 720 children in pairs abide in it";[1] the commentator Sāyana explains that the

[1] I. 164.

twelve spokes represent the twelve signs; and the "720 children in pairs" are the 360 days and 360 nights in the Year-Cycle. Again, there were the 12 *Ādityas* or Solar Entities of the *Veda,* which appear to have been personifications of the divisions of the ecliptic. My reasons for regarding them as constituents of a solar zodiac are these: (1) *Ādityas* are the offspring of *Aditi,* and if the latter meant an "Enclosure" (see § 1), like the ecliptic, the *Ādityas* are easily seen to be merely divisions of this enclosure; (2) some of them are distinctly connected with the ecliptic and its divisions, e.g. one of them is *Dakṣa Prajāpati* (see § 1); another is *Pushan,* the Goat-god, called "the son of *Prajāpati*"; two others *Indra* and *Agni,* also *Prajāpatis,* are identified (by Plunket) with the summer solstice and the winter solstice; (3) there are distinct statements in the *Brāhmaṇas* that "the twelve *Ādityas*" were "fashioned after the Sun," and that they were the same as "the twelve months of the year";[1] (4) the reason for these Solar Entities being known by different names is understood by comparing it with the similar Akkadian habit of calling *Merodāch,* the Solar God, by various names in the various months, e.g. *Sulpa-Uddu* in *Niṣan, Ut-ul-tar* in *Iyyar,* etc.[2] The *Ādityas* therefore appear as different manifestations of the same Sun-god in the twelve stages of his journey through the ecliptic.

These twelve divisions were fundamental, and were not necessarily dependent on the number of full moons

[1] Cf. *Sa. Bra.* VI. 1; 2; 8–10; XI. 6; 3; 5–10; etc.
[2] Cf. A. H. Sayce: *Astronomy and Astrology of the Babylonians,* p. 166.

in the year—though, no doubt, the experience that there were twelve full moons in the year must have strengthened the faith of the people in the significance of this number, and persuaded them to select this scale for representing the months. Thus one of the earliest sets of months was that of "seasonal-months," *Madhu*, *Mādhava* (honey, sweet spring), . . . *Nabhas*, *Nabhasya* (rainy, vapoury), etc., which were only twelve equal parts of the year, named meteorologically, and with no reference to the moon; the *Ṛig-Vedic* months were only "*twelve* artificial periods" of 30 days each; in the *Sāma-sūtras* we find twelve sidereal months of 27 days each in a sidereal year of 324 days, etc.,[1] showing that the "month" was only one of twelve divisions of a cycle called the year. The sacredness of the number *twelve* can be seen from the following passages in the *Śatapatha Brāhmaṇa*: "And as to why there are twelve (flowers)—there being twelve months in the year, and the year being All, it is by the All that he thus initiates him: what flowers there are of the lotus, they are a form (an image) of the sky, they are a form of the stars . . .";[2] "Twelve *Āpri* verses there are—twelve months are a year, and the year is *Agni*. . . . And, again, why there are twelve, of twelve syllables consists the *Jagatī*, and the *Jagatī* is this earth."[3]

The reference to the twelve flowers as an image of the sky and of the stars leads us on to the *picture-theory* of the origin of the zodiacal constellations. The *Yajur-Veda*[4]

[1] *Nidāna Sūtra*, V. 11, 12.
[2] V. 4; 5; 14. [3] VI. 2; 1; 28, 29.
[4] V. 5; 11; 49; VI. 6; 4; 17; cf. also *Shāmaśāstry*: *Gavām Ayana*, pp. 28, 83 *et seq.*

gives a list of sacrificial victims: Pig, Deer (or Beast), Bull, Tiger, Monkey, Sparrow, Snake, Red Animal sacred to the moon (Hare), Crocodile, Elephant, and *Rat*; these are seen to be not very different from the animals of the Chinese Zodiac which begins with the Rat (Aquarius).[1] If these animals were not available for the sacrifice, their *pictures* on cloth are sanctioned as appropriate substitutes. Thus the "animals" supposed to be sacrificed were only symbols of the zodiacal divisions which were passed by the sun at an epoch marking the end of a cycle: these symbols might have been originally an animal or a flower, or else its picture; the animal-pictures were later on transferred to the skies and utilized to group together the stars in the vicinity of the ecliptic so as to form a Zodiac. The use of the pictures in the sacrifices suggests the employment of a square of "twelve houses" *in* which the pictures were placed, considering the arrangement of several objects in a Hindu ritual.

§ 3. The *Nakshatras*

Weber has shown that the *Nakshatras* were *primarily* "divisions" of the ecliptic, which were represented by the constellations. They are called the daughters of *Dakṣa Prajāpati* (the ecliptic), and the wives of the Moon-god, who was finally compelled to dwell *equally* with them.[2] An account in the *Mahābhārata* goes on to say that these wives of the moon "are employed in indicating time, and they are (called) *Nakshatras* or *Yoginīs* (so-called) for

[1] See Appendix I, cols. 6, 7.
[2] *Kāthaka Samhita,* XI. 3; *Taittirīya Samhita*: II. 35; 1–3; III. 4; 7; 1; *Sa. Bra*: IX. 4, 1, 9; etc.

assisting the courses of the worlds."[1] They were used in the *Brāhmaṇa*-period to denote dates, and to specify the time of a sacrifice, for instance, to be held "in" a particular *Nakshatra.* The *Nakshatras* were usually assigned a definite extent or "duration": either equal periods of one day each, or different periods of 1 day, 1½ days, and ½ day. These "durations" cannot be explained if we suppose that the *Nakshatras* were primarily asterisms; for an asterism does not usually extend over the whole of the corresponding division—some of them being only single stars—so that the moon cannot be in "conjunction" with this asterism for the given period, as Thibaut supposes; nor are they single stars limiting and determining intervals of the ecliptic. All this shows that the *Nakshatras* were *essentially* longitudinal divisions, and that the constellations were chosen later to symbolize the divisions and called by the same names. This explains why some of the star-groups of the *Nakshatras*, e.g. *Puṣya* (γ, δ, θ Cancri), are so faint that they could hardly have been selected as members of an independent series of constellations: their selection was evidently due to the lack of better material in the neighbourhood to form a concrete representation of those divisions.

The *Nakshatras* seem to have been occasionally regarded as entirely independent of stars. The *Śatapatha-Brāhmaṇa*[2] states that the *Kṛittikās* are stationed in the east, as though the *Nakshatras* formed a tropical scale,[3]

[1] I. 66, 6; also see XII. 343, 5; XII. 207, 24, etc.
[2] II. 1; 2; 2–4.
[3] Bentley regarded the *Nakshatras* as "Tropical Lunar Mansions"—cf. his *Hindu Astronomy*.

whose eastern division, coinciding with the vernal equinox, was called "*Kṛittikās.*" Again, the *Sūryaprajñapti* states that "the stars travel faster than the *Nakshatras.*" And in the *Purāṇas* we are told that the *Saptarshis* (the Great Bear) move among the *Nakshatras,* completing one revolution in 2,700 years. From these Kaye[1] suggested the hypothesis that the *Nakshatras* formed a sort of sliding scale.

As regards the question of priority of 28 or 27, as the number of divisions of the Zodiac, though 27 is the prevailing number in the early Vedic lists of *Nakshatras* and in other works, yet there is sufficient evidence for considering that 28 could have been the original number. The account of the *Nakshatras* as the wives of the moon in the early *Samhitas*[2] does not mention their number as 27. The *Taittirīya Brāhmaṇa* gives a list of 28 *Nakshatras,* though the list comprises only 27 in another place of the same book. The *Maitrāyaṇī Samhita* (II. 13, 20) and the *Atharva Veda* (XIX. 7; 1; 81) make them 28; the Atharvan hymn might, as Whitney pointed out, be as old as any other Vedic hymn, considering how the traditional materials had to wait for ages before they were gathered together in the later age of composition of the *Vedas.* The *Mahābhārata*[3] contains a distinct reference to an earlier system of 28 divisions, from which the extraneous

[1] Cf. *Indian Antiquary,* Vol. 50; also Kaye's *Hindu Astronomy,* p. 23.

[2] The *Taittirīya Samhita* makes them 33; while the *Kāthaka Samhita,* etc., give no number.

[3] III. 230, 2; the number 28 has been supposed to be implied by some passages, e.g. V. 110, 5; IX. 34, 6.

Nakshatra, *Abhijit*, somehow disappeared: "The lady *Abhijit*, the younger sister of *Rohiṇī*, being jealous, has repaired to the woods to perform austerities, and I am at a loss to form a substitute for the fallen star." In the later astronomical texts there are scales of 28 *Nakshatras*, though these are of unequal extent.

In these texts, beginning with the *Sūryaprajñapti*, the total extent of the 28 *Nakshatras* is nearly $27\frac{1}{3}$ days—the fraction being the extent of the additional *Nakshatra Abhijit*—and this has naturally supported the theory of the origin of the system by observation of the sidereal period of the moon, counted first as 27 days, and later corrected by the addition of *Abhijit* of the extent of $\frac{1}{3}$ day or thereabout. But in some earlier works the system is seen to have no such simple relation to the moon's period. The *Nakshatra-kalpa* makes *Abhijit* extend only over 1 *muhūrta* ($\frac{1}{30}$th day), the others being given the usual extents, viz: 6 *Nakshatras* of $1\frac{1}{2}$ days each, 15 of 1 day each, and 6 of $\frac{1}{2}$ day each; thus totalling $27\frac{1}{30}$ days, which is surely not the moon's period to the approximation indicated by the fraction. *Pushkarasārin's* MS. gives "7 or 8" *muhūrtas* to *Abhijit*, 30 *mu.* to each of 16 *Nakshatras*, 45 *mu.* to each of 6, and 15 *mu.* to each of 5; thus amounting to a period of 832 or 833 *mu.* =27·733 or 27·767 days; this is nearer to 28 days than to the sidereal period of the moon or to the number 27.

Even the extents of the *Nakshatras* in the *Sūryaprajñapti* appear to have been obtained by correcting a period of 28 days rather than 27 days. I have noticed a certain regularity in their extents that can be shown

by arranging them in groups of four, beginning with *Aświnī*:

1, ½, 1, 1½; 1, ½, 1½, 1; ½, 1, 1, 1½; 1, 1, ½, 1½;
1, ½, 1, 1; 1½, 21/67, 1, 1; ½, 1, 1½, 1 days.

Each group of four—except the fifth and the sixth—consists of 2 *Nakshatras* of 1 day each, 1 *Nakshatra* of 1½ days, and 1 of ½ day,[1] thus amounting to 4 days. The fifth and sixth groups are in the vicinity of *Abhijit*, and were probably altered when the original system was adjusted to the period of the moon. This original system probably consisted of 7 similar groups of four days each, amounting to *28* days.

Such a period of 28 sidereal days seems to have been known in earlier times, and was probably connected with the number 27 by a characteristic process of reasoning. The *Jyotiṣa Vedāṅga* refers to a "lunar day" as the period from moon-rise to moon-rise. If we suppose that the *Nakshatras* had been at some time intimately connected with the moon, and the "lunar day," or the interval between two successive risings of the moon with two "asterisms," was considered as the time taken by the moon to traverse one of these ecliptic divisions and consequently called a *Nakshatra*, a period corresponding to 27 such lunar days could have been regarded as completing the cycle; this is equivalent to 27 (1 + 1/27) or

[1] The *Nakshatras* were classified (*a*) into three kinds according to their extent: *Samakshetra* (mean field), *Dvyartha-kshetra* (1½ field) and *Apārdha-kshetra* (½ field); (*b*) into four classes connected somehow with the parts of the day: forenoon and afternoon (mean field), nocturnal (½ field), and dual (1½ field).

28 sidereal days, and was perhaps the original *Nakshatra* month. The numbers 28 and 27 might have been simultaneously used for some time with this relation understood between them; later this might have given place to the 27 *Nakshatras*, and, later still, the "lost *Nakshatra*" *Abhijit* was added so as to adjust the system to the sidereal period of the moon.

There is thus substantial evidence in favour of the conclusion that the *Nakshatras* were originally a scale of *28 divisions*, capable of representing time-intervals as well as spaces. They could therefore have arisen by the method of divisions described in Chapter II.

§ 4. Other Divisions of the Ecliptic

The division of the circle into sixty parts was familiar to the Hindu astronomers. Brahmagupta (seventh century A.D.) seems to have used such a graduated circle, and an earlier use of units of angle of 6 degrees each will be found in the calculations of the following chapter. The Indian units of time—and time-intervals were equivalent to zodiacal divisions—were based on the number 60: thus a day was divided into 60 *nāḍis* even at the time of the *Jyotiṣa Vedānga*; a *nāḍi* or *ghati* into 60 *palas*; a *pala* into 60 *vipalas*, each of which was divided into 60 *prativipalas*. We also find in India the division of each degree into 60 *kalas*, and each *kala* into 60 *vikalas*.[1] The early scale of *60* divisions might have given rise to the important Jupiter cycle: this cycle is supposed to be derived from the earlier *Jyotiṣa* cycle of 5 years (of 62 lunations),

[1] Cf. Sewell and Dikshita: *Indian Calendar*, pp. 2, 9.

either as an attempt to dispose of the couple of additional months by taking 12 such cycles,[1] or as an attempt to include the motion of Jupiter in the earlier cycle, so that the sun, moon, and Jupiter will return to the same *Nakshatra* at the end of 60 years; these two schools give the years two different sets of names.[2] There is a third and more usual set of names, in which each year is called by a different name, beginning with *Prabhava*: this represents the original scale of 60 divisions, whose existence was taken advantage of by those who wanted to dispose of the additional months in the 5-year cycle or those who wanted to combine with it the motion of Jupiter. Even the greater cycles of the Hindus were probably derived from the sexagesimal system, by using one division to represent a smaller or a bigger unit: the "Ages of the World," the *Kali-Yuga*, the *Dvāpara-Yuga*, the *Treta-Yuga*, and the *Kṛita-Yuga* are seen to be 2×60^3, 4×60^3, 6×60^3 and 8×60^3 years; the *Chatur-Yuga* is 20×60^3 or $\frac{1}{3}$ of the Platonic Number, which was also known to the Babylonians:[3] these periods were utilized by the astronomers to include the motions of nodes, apsides, etc., in their cycles.

The scale of 124 divisions appears in the *Jyotiṣa Vedānga* division of the *Nakshatra* into 124 *amśas* (or *bhāmśas*) or parts.[4] It is implied that the new and full moons occur

[1] Somākara, the commentator of *Jyotiṣa Vedānga*, names the 12 groups so formed. Cf. Weber: *Veda-Kalendar*, p. 24.

[2] The second set is named like the 12 lunar months, *Kārttika*, *Mārgaśīrṣa*, etc.; this set is repeated 5 times in order in the cycle.

[3] Cf. H. V. Hilprecht: *Mathematical Tablets.*

[4] Cf. *J.A.S.B.*, 1877, pp. 425–32.

in the 1st, 2nd, 3rd . . . 27th *amśas* of the *Nakshatras* 6, 11, 16, 21, 26 . . . 18, 23, 1, these *Nakshatras* recurring for the rest of the *amśas*—as though these latter numbers were written consecutively in the 124 squares of our scale. The same book uses the number in dividing another unit: the *kalā* (= 1/603 day) is divided into 124 *kāṣṭhas*. A similar calendar, the *Garga-Samhita*[1] divides the civil day into 124 *lavas*.

Colebrooke[2] refers to the sub-division of each *Nakshatra* into 9 *tārahs*, called *Janma, Sampad*, etc.; they each answer to a day, and are consequently repeated in their order three times in the *Nakshatra māsa* of 27 days. If these sub-divisions were known when the *Nakshatras* were 28 in number, there would be 28 × 9 or 252 sub-divisions in the circle—this is the number derived by division of the scale of 124 squares.

Of the second series (Chapter II, § 2), the number *36* played a prominent rôle in the *Vedas*: 36 days are stated to belong to an intercalary month, showing how the priests waited till the number of intercalary days to be added as a correction to the adopted value of the year amounted to the stipulated period of 36 days; again, they attached a cosmic significance to the metre of 36 syllables—also to the syllable—as is seen from this passage: "This very same legend revolves again and again for a year. . . . For thirty-six ten-day periods, he tells it—the *Bṛihati* metre consists of thirty-six syllables, and cattle are related to *Bṛihati* metre: by means of the *Bṛihati*, he

[1] Weber: *Veda-Kalendar*, p. 33, 35 *et seq.*

[2] *Miscellaneous Essays*, Vol. I, p. 25 *et seq.*

thus secures cattle for him."[1] The scale of 36 divisions appears in the 36 *Drekkanas* of Varāhamihīra, each of which is equal to 10 degrees—though he treats them as 3 sub-divisions of a sign.[2]

The scale of 108 divisions can be seen in the *Navāmśas* of Varāhamihīra. Though these divisions are treated as 9 parts of each sign, the continuity of the scale is seen from the fact that the divisions are governed by the Lords of the signs repeated 9 times in cyclic order: thus the *Navāmśas* of *Mesha* (Ram) are governed, not by the the Lord of the 1st sign, but by those of the 1st, 2nd . . . 9th signs; the next 9 divisions by the Lords of the 10th, 11th, 12th, 1st . . . 6th signs; and so on. The number 108 appears earlier in the *Mahābhārata*,[3] which gives 108 names to the sun; if these names were analogous to the 12 *Ādityas*, they would represent 108 divisions of the ecliptic.

Part of the second series (Chapter II, § 2), up to the number 108, appears in connection with the dimensions of a house laid down by Varāhamihīra: in the chapter "On Architecture," in his astrological treatise *Bṛihat Samhita*, he says: "The largest of the five houses of a king should be of 108 cubits in width; the following of 100, 92, 84, 76."[4]

These instances are sufficient to show how the ancient Āryans might have used a series of borders of squares to represent the different cycles or the different gradua-

[1] *Sa. Bra.*, XIII. 4; 3; 15; also see Shāmaśāstry's *Gavām Ayana* for an explanation of the "Cows" (or cattle) as intercalary days.
[2] *Bṛihat Jātaka*: Chapter I; Stanzas 6, 11.
[3] III. 3. 11.
[4] Chapter LIII, verse 4.

tions, and how the cyclic order enabled them to establish some correspondence between the "houses" of these different scales.

§ 5. The *Chakras*

The Square Zodiac used by the astrologers in India even to-day, from which we set out to arrive at the different series of scales, is called the *Rāśi-chakra* or the "Wheel of Signs." The signs are, in astrology, technically

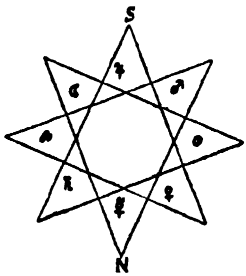


FIG. 7

called "houses," a name which is appropriate to the small squares, rather than to lineal divisions of the circle. Varāhamihīra[1] states that the 1st, 4th, 7th, and 10th signs are also designated *Kanṭaka* ("Pointed"), *Kendra* ("Corner"), etc.—which again properly refer to our Square Zodiac.

Another *chakra* known to the ancient Āryans was the *Rāhu-chakra* (Fig. 7).[2] This is the eight-pointed star obtained by joining every fourth point of a regular octagon by a continuous line, so as to form a closed polygon;

[1] *Bṛihat Jātaka*, Chapter I, Stanza 17.
[2] Cf. Al-Biruni's *India*, Vol. I, p. 292 *et seq.*

while the eight points of the star were utilized to denote the eight directions, the eight angles were presided over by the seven planets and the demon Rāhu, which was considered by Hindu astronomers to be another planet, causing eclipses. Probably this "new planet" gave its name to the wheel.

Al-Biruni gives another division of the directions according to the *Nakshatras*.[1] He assigns 3 *Nakshatras* to each of the eight directions, and states that this is called the *Kūrma-chakra* (the Tortoise-wheel) because of

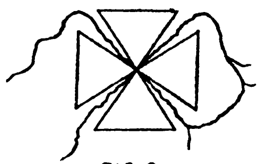


FIG. 8

the belief that the earth resembles the back of a tortoise; but his set of *Nakshatras* is incomplete, involving the omission of 3 important *Nakshatras—Kṛittikās, Rohiṇī,* and *Mṛiga-śiras* (Pleiades, Hyades, and the head of Orion)—and, of course, *Abhijit*. Hewitt,[2] however, draws the tortoise-wheel as in the annexed figure (Fig. 8), which divides the *earth* into four triangular territories, with rivers flowing in the valleys between. It is interesting to note that, if the cleavages between the lands be joined, by raising the centre and allowing the adjacent edges of the triangles to coincide, we get a *pyramidal* "tortoise" representing the earth, and a *square* "tortoise-wheel"

[1] *India*, Vol. I, p. 296.

[2] *Ruling Races of Prehistoric Times*, etc., p. 320.

forms the horizontal boundary: the "tortoise-back" is no more spherical than the "wheel" is circular.

Another *Chakra* is what is called the *Śrī-chakra*,[1] or "the wheel of the Goddess of Wealth." This is a 64-pointed star, supposed to banish all misfortune by its proximity. Its connection with the ecliptic can be seen from some of the common names of the Zodiac, such as "the Wheel of Fortune" or "My Lady's Wheel," etc. We may also remember that this "Goddess of Prosperity" as well as the "Goddess of Earth" was represented in the Vedic Age by *Aditi*, the mother of the *Ādityas*.

Thus the ancient zodiacs were not always circular; though they were called *Chakras* or "wheels" in India, these wheels were not necessarily circles, but were the names given to *any closed polygon*: "*chakra*" simply meant a "revolution" or a recurring cycle. Further, these pointed wheels might have been different stages in the development of the Zodiac from the square to the circular shape.

§ 6. The Earth and other Bodies

Besides these references to the horizon as an enclosure like the ecliptic, the earth is expressly stated to be "four-cornered" in the *Ṛig-Veda*.[2] This agrees with the mention in the same book of the "four quarters," *pradiśah*,[3] a

[1] Monier-Williams's *Sanskrit Dictionary* gives its meanings as: "a kind of magical circle used in the worship of *Tripura Sundarī*; a wheel of Indra's car; the circle of the Earth or globe." This is not really a circle. All these *chakras* are associated with the magical art, just like the "Wizard's Foot" or the five-pointed star, introduced into the west by Pythagoras.

[2] X. 58. 3.

[3] I. 164. 42.

term used, in an earlier part of the book,[1] to denote the earth. Other passages, however, make it "five-pointed";[2] the *Atharva Veda* increases the points to six, and even seven; these seven points may have been meant by the seven "places" (*dhāma*) and the seven directions (*diśah*) of the earth, mentioned by the *Ṛig-Veda*.[3] The *Ṛig-Veda*, again, compares the earth to a wheel,[4] which is usually taken to mean that the earth "was naturally regarded as circular"; but I have shown above that the "wheel" may be any *enclosure*, not necessarily circular; the circular shape is ascribed to the earth, in the *Śatapatha Brāhmaṇa*, by the term *parimaṇḍala*. But even the latter book reverts to the quadrangular shape of the earth, and the importance of this shape in the rituals: "Now this earth is four-cornered, for the quarters are her corners: hence the bricks are four-cornered; for all the bricks are after the manner of this earth."[5] This shape gave the earth the name *Chatur-antha*, "bordered on all *four sides*."[6] Thus the *chakra* of the earth was originally a quadrangular enclosure, but later on became five-pointed, six-pointed, seven-pointed, and finally developed into a circle.

Another object of astronomical importance seems to be fashioned in the square shape. *Indra*, the chief of the Vedic *Prajāpatis*, wields "a powerful *four-cornered Vajra*,"[7] with which he slays the demon *Vṛitra*, also referred to as *Ahi*, the Serpent; this might symbolize the opposition of

[1] IX. 86. 29; also *A.V.*, III. 24. 3, etc.
[2] IX. 114. 3; I. 22. 16.
[3] IX. 114. 3.
[4] X. 89. 4.
[5] *Sa. Bra.*, VI. 1; 2; 29.
[6] Cf. Monier-Williams's *Dictionary*.
[7] *Ṛig-Veda*, IV. 22. 2.

the summer solstice to the winter solstice,[1] and *Vajra* may be connected with the ecliptic. In later mythology, we have *Vishnu,* the chief of the gods, wielding the *chakra* as a weapon to slay the enemies.

Another body with this attribute is the sun: the *Śatapatha Brāhmaṇa* says[2] that the sun "is *four-cornered,* the four quarters being his corners." While this literally refers to the shape of the sun, it is also possible that it may contain a hidden description of the shape of the sun's orbit.

§ 7. The Square in Āryan Architecture

The square shape, as such, as well as the "borders" or "gnomons," was familiar to the Vedic Āryans and utilized by them in the construction of their *altars* and other buildings. The *Ṛig-Veda* contains references to "cities with a hundred enclosures,"[3] which, according to Muir,[4] suggest the actual plans of the cities or forts existing in the country at that time. The villages[5] had generally *four* main gates at the middle of *the four sides,* and as many at *the four corners*; the gates on the opposite sides were connected by two large streets which intersected a street running all round the border; the village was thus divided into *four* main blocks, and the plan (Fig. 9) is exactly our "cardinal figure" (Chapter II, § 1).

The rules for the construction of the buildings were

[1] Hillebrandt considered *Vṛitra* as the Winter Monster of Snow, etc., melting before the heat of Summer; Plunket regards *Indra* as the Solstitial Sun defeating the demon of Draught, *Vṛitra.*

[2] *Sa. Bra.,* XIV. 3; 1; 17.

[3] I. 166. 8; VII. 15, 14.

[4] Muir: *Sanskrit Texts,* V. 451.

[5] Cf. P. K. Āchārya: "Indo-Persian Architecture," *Calcutta Review,* April 1930, p. 24.

embodied in the *Kalpa-sūtras*, which also contained the *Śulva-sūtras* (rules for the use of the "rope"). These contain, besides the so-called Pythagorean theorem, "the occurrence of indications of the formation of a square by the successive addition of gnomons."[1] The process for the extension of an altar (the sevenfold *agni*) consisting of 225 bricks, is described as follows: "To these (225 bricks) sixty-four more are to be added. With these bricks a square is formed. The side of the square consists of sixteen bricks. Thirty-three bricks still remain, and these

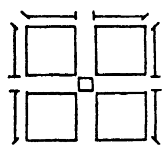


FIG. 9

are placed on all sides round the borders." The process is the same as the method of "bordering" (Chapter II, § 2); only it is here completed in two stages by the addition of two Pythagorean gnomons, first one of 31 bricks so as to form a square of side 16, and again 33 more so as to form the bigger square of side 17; the final stage is represented by a "complete border" of 64 bricks "placed *on all sides* round the borders." The square shape of each brick is comparable with our unit squares.

In later periods the square shape gave way to the circular, and even intermediate stages are discernible in architecture. The villages and halls are classified according to the different shapes of their plans; the *Matsya-*

[1] Kaye: *Indian Mathematics*, p. 5; 4; cf. also Thibaut: "On the Śulva-sūtras"; *J.A.S.B.*, Vol. 44, No. 3, pp. 227 *et seq.*

purāṇa states that these halls "may be triangular, crescent, circular, quadrangular or square, octagonal, and sixteen-sided."[1]

Still, the square shape and the gnomonic arrangement persisted to a large extent. Varāhamihīra[2] divides the plan of a house into 64 squares, guarded by 45 deities; these are distributed over the squares so that the jurisdiction of a deity extends over one square, or two squares, or half a square, and for this purpose the squares at the

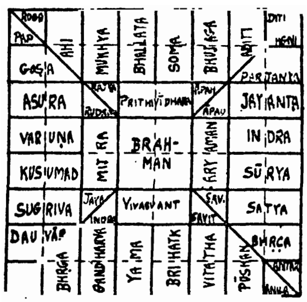


FIG. 10

corners are divided by diagonals. The adjoining figure (Fig. 10) is given in Kern's translation of the *Bṛihat Samhita* (p. 18).

An analysis of the figure discloses the arrangement of the squares: (i) 4 squares in the centre are assigned to *Brahma*, Cosmos or Creator; (ii) this is surrounded by a border of 12 squares reigned over by 12 deities, though Varāhamihīra gives 2 squares to some and half to others; (iii) the next ring of 20 squares is left without any deities;

[1] *Matsya-purāṇa*, Chapter 270, verses 7–15, 16, etc.; also P. K. Āchārya, *loc. cit.*

[2] In the chapter on "Architecture," *Bṛihat Samhita*, Chapter LIII, cited before.

and (iv) the next ring of 28 squares is presided over by 32 deities, the deities at the corners being limited to half a square, while the others extend their jurisdiction to the neighbouring ring of 20 squares. It is easy to see how Varāhamihīra (or some predecessor) obtained this arrangement from the original scheme described in Chapter II of the present work. That such alterations must have taken place can be inferred from the fact that Varāhamihīra himself describes an alternative method for housing these 45 deities: "draw ten lines from east to west, and ten others from north to south. Thirteen deities occupy the interior; thirty-two are stationed in the outer compartments."[1] Here the 49 inner compartments are all re-grouped by drawing diagonals across some of them, and assigning them to the care of 13 deities, while the 32 outer compartments—forming a complete border ($9^2 - 7^2$)—are each assigned one deity.

§ 8. The Fire-Altar and the Universe

The earliest altars must have been built in the shape of squares. "The most ancient and primitive form" was the "square-Eagle-Altar" (*Chatura-śyena-chit*) probably so called originally because of its square shape, and because of the Vedic habit of associating astronomical entities with a "bird" as a figure of speech, e.g. "Sun-Bird"; this was misunderstood by the priests as a literal description of the altar, which was figured like an eagle, thus leading Thibaut to explain that the altar was "so called because it rudely imitates the form of a falcon,

[1] *Loc. cit.*, V. 42.

and because the bricks of which it is composed are all of a square shape"![1] The square altar gradually developed into the circular altar; so much so that the question whether the shape of an altar to be built on a particular occasion should be square or circular caused great doubts and a cleavage of opinion among the priests—it was this confusion that necessitated the invention of methods of converting a square into a circle of equal area and *vice versa.* Among the 8 classes (15 varieties) of altars described by Thibaut, some deserve mention here: (1) the "Tub-Altar" (*Drōṇa-chit*) can be of two varieties, the circular (*parimaṇḍala-drōṇa-chit*) and the square (*chaturaśra-drōṇa-chit*); (2) the "Tortoise-Altar" (*Kūrma-chit*) is again of two varieties, the circular (*parimaṇḍala*) and the angular (*varānga*). It is important to notice the analogy provided by these altars to the *Rāśi-chakra* and the *Kūrma-chakra* (§ 5); especially with reference to the view expressed above that the circular shape was not necessarily meant by the terms *Chakra* (wheel), or *Kūrma* (tortoise), but only by the term *parimaṇḍala.*

The connection of the altar with the divisions of the Zodiac (*Prajāpati*, year, etc.), and the Universe appears in numerous passages of the *Brāhmaṇas*. In a very curious passage,[2] the *Śatapatha Brāhmaṇa*, after stating that "the Fire-altar is the Universe," proceeds to describe it as built of 756 bricks, equal to the total number of the *Nakshatras*; this number is explained as the product of the 27 *Nakshatras* into the 27 "secondary" *Nakshatras*—

[1] Thibaut: *J.A.S.B.*, Vol. 44, No. 3, pp. 229–30.

[2] X. 5. 4. 5; also cf. Weber: *Naxatra*; Theil II, p. 298; Macdonnel and Keith: *Vedic Index—Nakshatras.*

counted as 720—with the addition of 36 days (of the intercalary month). All this is usually taken as "priestly nonsense" from which nothing useful can be derived. But it has to be noticed that $756 = 28 \times 27$. Perhaps the book may be referring to the existence of two *kinds* of *Nakshatras*, primary and secondary, which were originally 28 and 27 respectively; these appear in a connected form in the *Nakshatra*-month of 27 "lunar days" or 28 sidereal days, the "lunar day" or the period from moon-rise to moon-rise, and the sidereal day or the period between two successive risings of an asterism, being supposed to be the two kinds of *Nakshatras* (see § 3). The *Nakshatra* scale of 28 squares could form the plan of the altar; and on this 27 layers of bricks can be placed representing the 27 asterisms (secondary *Nakshatras*) rising in each sidereal day; so that the fire-altar is built up of 756 bricks representing the 756 *Nakshatras* that can be observed from any point to rise in the period of 27 lunar days or 28 sidereal days. The shape of this reconstructed altar conforms to the definition of the shapes of the altars: it is of the variety of the *square-Tub* (*chaturaśra-drōṇa-chit*). Those who wish to evoke the mystical properties of the number 27 ($= 3^3$) to claim priority for that number will feel some satisfaction in noticing that our fire-altar has its external width $= 2^3$, internal width $= 2 \times 3$, and the height $= 3^3$ layers, and may be regarded as endowed with the mystic properties befitting a model of the Universe.

The Universe, therefore, resembled such a fire-altar of a cuboidal shape.

CHAPTER IV

HINDU ASTRONOMY (*continued*)
THE MERU COSMOLOGY

§ 1. Dimensions of Orbits in the Sūryaprajñapti

In the first chapter (§ 5) was described in brief a crude cosmology found in the Jaina astronomical treatise called the *Sūryaprajñapti*. This text[1] contains estimates of dimensions such as the sizes of the celestial bodies and of the orbits of the sun and moon, and the heights of their orbits. The inner circle of the Sun (i.e. the circle traversed on the day of summer solstice) is stated to be 99,640 *yojanas* in "diameter" (*vishkambha*); this falls within 180 *yojanas* of the boundary of *Jambu-dvīpa* (the earth); the diameter of the outer circle is 100,660 *yojanas*. The circumferences of these circuits are also given as 315,091, 316,227, and 318,315 *yojanas* respectively—answering to a value of $\pi = 3{\cdot}16227$ or $\sqrt{10}$ (nearly). Again, it is stated that the sun's chariot moves at a height of 800 *yojanas* above the ground. We are also given another measure, regarding the position of the observer: the sun *appears* to descend at the winter solstice only because he has receded from "us" to the amount of 550 *yojanas*. Thibaut passed by most of these figures with the comment that they were mere theological details not worth the attention of a modern scientific investigator!

[1] Book I, Chapter VIII; also cf. G. Thibaut's article in *J.A.S.B.*, Vol. 49, 1880, pp. 118 *et seq.*

Professor Filon was the first to draw my attention to the importance of these early estimates. If these numbers were the results of actual observations and calculations, the distance between the two solstitial positions must subtend at the observer an angle equal to twice the obliquity of the ecliptic; the position of the observer must therefore lie on the arc of a circle standing on a chord equal to 510 *yojanas* ($= \frac{1}{2} \times 100{,}660 - \frac{1}{2} \times 99{,}640$), and containing an angle of 46° 54′. The exact position of the observer is obtained by the intersection of this arc with

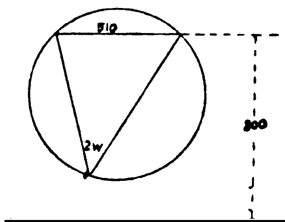


FIG. 11

a straight line drawn parallel to the chord at a distance of 800 *yojanas* (Fig. 11). Ordinarily this must give us two determinations of the position of the observer; but, unfortunately, the straight line and the circle do not meet at all.

§ 2. The Two Places of Observation

How, then, did the author of the work arrive at these figures? Even if they were mere theological details, what was responsible for the selection of these particular numbers, 100,660 *yojanas*, etc., in preference to more handy numbers? The clue is found in the dimensions of *Jambu-dvīpa*: this is given as 100,000 *yojanas*; this was certainly

not the result of direct measurement of the diameter of the earth, but must have been assumed just because it was a "round number," perhaps of the *order* to which the earth's size was believed to belong. Starting from this number, they must have got the other numbers: observations must have been made at the extremity of *Jambu-dvīpa*. There was, again, the second place of observation, 550 *yojanas* from the winter solstice (measured horizontally, of course).

If we disregard the value of 800 *yojanas* for the height of the sun, which apparently introduces the incongruity into the calculations, and assume the value of the obliquity of the ecliptic ($\omega = 23° 27'$), we can calculate the latitudes of the places of observation.[1] The latitudes are found to be (i) 29° nearly, and (ii) 6° nearly.

[1] (i) Consider *the place* (O), (Fig. 12), which is 550 *yojanas* from *s*, the projection of the winter solstice, and consequently 40 *yojanas* from *n*, the projection of the summer solstice, on the ground.

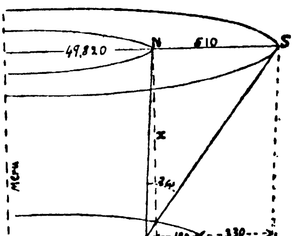


FIG. 12

Let x be the height of the sun's plane, λ the latitude of the place, and $\omega (= 23° 27')$ the obliquity of the ecliptic.

$$\text{Then} \quad \frac{x}{550} = \cot(\lambda + \omega)$$

$$\frac{x}{40} = \cot(\lambda - \omega)$$

[Note continued on page 79

The two places can correspond to (i) some place in north India, probably near Delhi, and (ii) some place in the south of the present Ceylon, which could possibly have been regarded as a sort of "Land's End."

However, the height of the sun is different for the two places, and different from 800 *yojanas*. Calculation shows

Note continued from page 78]

$$\therefore \frac{550}{40} = \frac{\tan(\lambda + \omega)}{\tan(\lambda - \omega)}$$

$$\therefore \frac{590}{510} = \frac{\tan(\lambda + \omega) + \tan(\lambda - \omega)}{\tan(\lambda + \omega) - \tan(\lambda - \omega)} = \frac{\sin 2\lambda}{\sin 2\omega}$$

whence $2\lambda = 57° \ 38'$ or $\lambda = 28° \ 49'$ or $29°$ (approximately).

(ii) If a perpendicular be drawn from the extremity of the earth (E) (Fig. 13) to the plane of the sun's orbit, the distances from the foot of the perpendicular to the summer and the winter

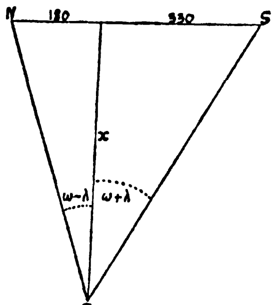


FIG. 13

solstices will respectively be (50,000 — 49,820 =) 180 *yojanas* and (50,330 — 50,000 =) 330 *yojanas*. Also, the inclinations of this vertical line to the solstices are $\omega - \lambda$, and $\omega + \lambda$, where λ is the latitude of E.

$$\frac{330}{180} = \frac{\tan(\omega + \lambda)}{\tan(\omega - \lambda)}$$

$$\frac{510}{150} = \frac{\tan(\omega + \lambda) + \tan(\omega - \lambda)}{\tan(\omega + \lambda) - \tan(\omega - \lambda)} = \frac{\sin 2\omega}{\sin 2\lambda}$$

From this we get, $2\lambda = 12° \ 24'$

or $\lambda = 6° \ 12'$ approximately.

the height to be about 426 *yojanas* at the first place, and about 580 *yojanas* at the second.[1]

§ 3. Rectangular Orbits

The question therefore still remains, how did they arrive at the figure 800 *yojanas* for the height of the sun? It is possible to show that the number 800, far from being a mere theological detail, holds good for a *Square-cosmology* that might have been the basis of the *Sūrya-prajñapti* or (more probably) of an earlier scheme. I have already mentioned the attitude of the work towards *phenomena,* many of which, like rising and setting or the changes of altitudes, were looked upon as mere *appearances* or illusions, due to other *real* factors. This suggests that the *real* paths of the sun might have been regarded as different from the apparent circular forms, and perhaps as rectangular. Xenophanes of Colophon is said to have taught the doctrine that "the motion of the celestial bodies is rectilineal, the circular forms of their daily paths being only an illusion caused by their great distance." In such a case the *vishkambha* or "size" of the orbit represents the side of a square, instead of the diameter of a circle. The corners of the square represented the solstitial positions, as might have already appeared from the last chapter, and as will appear more clearly in the subsequent chapters. The earth and the

[1] (i) $x = 40 \cot (\lambda - \omega) = 40 \cot (28° 49' - 23° 27')$
$= 40 \cot 5° 22' = 426{\cdot}0$ *yojanas*—at the first place.

(ii) $x = 180 \cot (\omega - \lambda) = 180 \cot (23° 27' - 6° 12')$
$= 180 \cot 17° 15' = 579{\cdot}7$ *yojanas*—at the second place.

orbits of the sun would then resemble the annexed figure (Fig. 14).

The true distances of the sun at the solstices will be

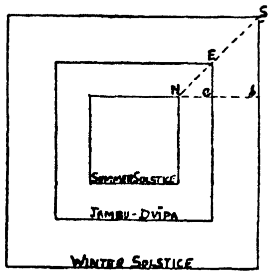


FIG.

N E, E S; while N*e*, *e s* give only the differences between the "sizes" of the orbits and that of the earth,

i.e. $\text{N}\,e = \frac{1}{2}(100{,}000 - 99{,}640) = \frac{1}{2} \times 360 = 180$ *yojanas*;
and $e\,s = \frac{1}{2}(100{,}660 - 100{,}000) = \frac{1}{2} \times 660 = 330$,,
$\text{N E} = \sqrt{2}.\text{N}\,e = 180.\sqrt{2}$;
and $\text{E S} = \sqrt{2}.e\,s = 330.\sqrt{2}$,
also E O (Fig. 15) = 800. From these, it is easy to calculate the inclinations of the solstices—

$$\omega - \lambda = 17^\circ\ 39';$$

and $$\omega + \lambda = 30^\circ\ 15'.$$

These equations give, by addition, $2\,\omega = 47^\circ\ 54'$,

or $\omega = 23^\circ\ 57'$, or 24° (approximately);

The latitude, λ, being $6^\circ\ 18'$.

Thus the height of 800 *yojanas* corresponds to an observation at a place of latitude nearly equal to 6°;

this could have been a place in the southern part of Ceylon, whose most southerly point (Dundra Head) lies in latitude 5° 56′ N. Allowing for inaccuracies of observation and computation, we could conclude that they had counted the southernmost extremity of the earth as lying in latitude 6°. Incidentally we notice that astronomers had been sent to Ceylon, even in that remote age, to observe the solstices. It is also important to notice that if the above is correct these astronomers had ob-

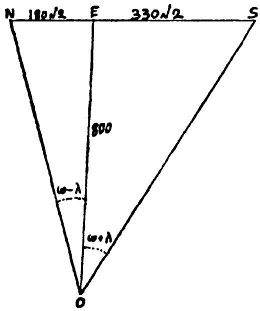


FIG. 15

tained the value of the obliquity of the ecliptic differing from the *correct* value by not more than half a degree; the obliquity was known to be 24° among most of the ancient nations; this is the figure given by the *Siddhāntas* also. It must be remembered that, while in the previous section the obliquity was assumed to obtain the latitudes, here both the obliquity of the ecliptic and the latitude have been obtained by merely taking the orbits to be square-shaped; the correctness of the value so obtained must be admitted to be a strong confirmation of the theory of a Square-cosmology.

Starting from this point, therefore, and assuming a large "round number" 100,000 for the size of the earth, they obtained the above figures for the dimensions of the sun's orbit. These numbers could be shown graphically to form a consistent system: the distance between the solstitial positions is $510.\sqrt{2}$, or 720 nearly; and a segment on a chord = 720 *yojanas*, and containing an angle of 48° ($= 2\,\omega$) meets a parallel line at a distance of 800 *yojanas*, giving real solutions (Fig. 16).

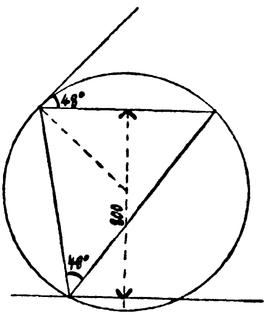


FIG. 16

An interesting point that has emerged from this solution is the square outline of the earth itself. This is a shape more appropriate than the circle to the descriptions of the *Sūryaprajñapti*, such as the division of *Jambu-dvīpa* into four quarters, of which the southernmost is *Bhārata* (India), and the northern one is another inhabited land *Airāvata*, while the eastern and western quarters are uninhabited lands. It is certainly easier—and æsthetically more satisfactory—to conceive of each of the quarters of the square as a square; also the two inhabited quarters, south and north of *Meru*, correspond to the south and north points. Again, what is also striking, the

southern quarter in this orientation has a rough resemblance to the actual shape of India (Fig. 17, *a*). On the other hand, if the earth-island had been circular, the southern quarter becomes a sector with a curved edge

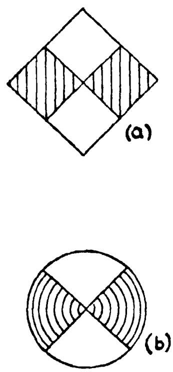


FIG. 17

and two straight edges tapering to a point, and the general resemblance to India is lost (Fig. 17, *b*).

§ 4. The Second Place of Observation

The statement that at winter solstice the sun recedes from "us" 550 *yojanas* may mean either (*a*) that the sun is actually at a distance of 550 *yojanas* from the foot of the perpendicular drawn from "our" position to the sun's plane, or (*b*) that the distance of the sun's path increases as in the last section, so that the actual distance from the foot of the perpendicular is $550\sqrt{2}$ *yojanas*.[1]

[1] In the second case (*b*),

$$\frac{550 \cdot \sqrt{2}}{40 \cdot \sqrt{2}} = \frac{\tan(\omega + \lambda)}{\tan(-\omega + \lambda)} \qquad \therefore \quad \frac{59}{51} = \frac{\sin 2\lambda}{\sin 2\omega}$$

Assuming $\omega = 24°$, this gives $\lambda = 29° \, 38'$, or $30°$ (approximately).

The second case, of course, is more probable, as it forms part of the same system as that of the previous section. This corresponds to a latitude of about 30°, and can refer to some place near Delhi. Hastinapura, the capital of Yudhiṣṭhira, was here, and was the centre of a high civilization at the period of the "Great War" of the *Mahābhārata*.

One characteristic of all the measures—of latitudes or of obliquity—may be noticed here. These are correct to the nearest degree, 6°, 24°, and 30°; that is to say, they are 1, 4, or 5 parts of a scale whose units are 6° each—showing the early use of sexagesimal graduations of the "circle."

§ 5. The Earth-Pyramid

The height of the sun from the second place of observation cannot, naturally, be the same as 800 *yojanas*. Perhaps the difference might have been accounted for by regarding the earth as a *pyramid* rising up towards *Meru* in a number of successive terraces. It is interesting to note that if we calculate the slope of an edge of such a pyramid it is found to be 36°.[1]

[1] The height of the sun's plane from the second point of observation O_2 (latitude $\lambda = 29° 38'$), can be found thus (Fig. 18):

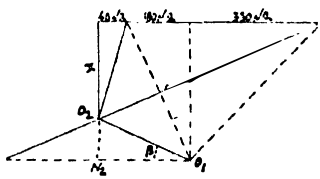


FIG. 18

[Note continued on page 86

The conception of the earth as a pyramid, fascinating in itself, is further suited to the geographical outlook of the Āryans in India. They saw the earth sloping down from the plateau of Tibet, down the Himālayas, on to the Gangetic valley, and again on to the plateau on the top of the Vindhya ranges and Central India; and once more sloping down to the sea in the south. Here were the number of successive terraces one below another, exactly as in the old pyramids of Egypt and Babylonia. The top of this pyramid might have been regarded as the base of Mount *Meru*, on whose summit lived the gods: *Meru* is still imagined to be one of the peaks of the Himālayas; while somewhere on the top of these high mountains, far away from the eyes of human beings, was *Kailāsa*,[1] the

Note continued from page 85]

If x be the required height,

$$\frac{x}{550 \cdot \sqrt{2}} = \cot(\lambda + \omega) = \cot 53^\circ\ 38' \text{ (assuming } \omega = 24^\circ)$$

This gives $x = 572 \cdot 8$ *yojanas*.

If the sun is still to be in the same horizontal orbit, at a height of 800 *yojanas* above the first position of observation O_1, the earth must be rising up like a pyramid from O_1 to O_2.

If O_2N_2 be $\perp r$ to the base, and β the slope of the edge of the pyramid—

$$O_2N_2 = 800 - x = 227 \cdot 20$$

and

$$O_1N_2 = 220 . \sqrt{2} = 311 \cdot 08$$

$$\therefore \quad \tan \beta = \frac{O_2N_2}{O_1N_2} = \frac{227 \cdot 20}{311 \cdot 08}$$

$$\therefore \quad \beta = 36^\circ\ 9' \text{ or } 36^\circ \text{ (approximately)}.$$

[1] On a plateau on the top of the Himālayas stands a big mound called Mount Kailāsa: on the four sides of this the Buddhist missionaries have built temples for worship, while the Hindu pilgrims worship the Mount itself. At the foot of the mound lies an octagonal lake called Manassarovar (cf. *Mānasa*), having eight temples built at its eight corners.

abode of *Śiva* (one of the Hindu Trinity) whose vehicle was *the Bull.*

§ 6. Pyramidal Meru

The pyramidal concept seems to have been carried by these people into the realm of the *centre* of celestial motions also: to Mount *Meru* is attributed a *square section* by a few among the diverse authorities quoted by Al-Biruni. "Brahmagupta quotes the following passage from the book of *Jina,* i.e. of Buddha: 'Mount *Meru* is quadrangular, not round.' "[1] The *Matsya-purāṇa* describes it thus: "It is golden and shining like fire which is not dulled by smoke. It has four different colours on its four different sides. The colour of the eastern side is white like the colour of the Brahmins, that of the northern is red like that of the *Kshatriya,* that of the southern is yellow like the colour of the *Vaiśya,* and that of the western is black like the colour of the *Śūdra.* It is 86,000 *yojanas* high, and 16,000 of these *yojanas* lie within the earth. *Each of its four sides has* 34,000 *yojanas.* There are rivers of sweet water running in it, and beautiful golden houses inhabited by the spiritual beings. . . . Round the mountain lies the pond of *Mānasa,* and around it on all four sides are the *Lokapāla,* i.e. the guardians of the world, etc."[2] The *Viṣṇu-purāṇa, Vāyu-purāṇa* and *Āditya-purāṇa* contain "similar statements about the four sides and the height of *Meru,*" and about "other related quadrangular mountains."[3] The *Viṣṇu-purāṇa* describes it as

[1] Al-Biruni's *India*, Chapter XXIII, p. 243.

[2] *Ibid.*, p. 247.

[3] *Ibid.*, p. 248 *et seq.*

a "seed-cup of the lotus of the earth," which is apparently conical; the dimensions are also given as height 84,000 *yojanas*, depth 16,000, base 16,000, and top 32,000 *yojanas*. With a square cross-section, the description of *Meru* would thus make it a huge, elongated pyramid, truncated and inverted.[1]

Though the Buddhists generally subscribed to the above beliefs, one strange idea appears in Al-Biruni, who states that he has no direct knowledge of Buddhist teachings, but that, according to Aleranshāri, "the Buddhists believe that *Meru* lies between the four worlds in the four cardinal directions; that it is square at the base, round at the top," etc.[2] This is probably an intermediate stage in

[1] The "base" and "top" are, in this case, defined by the lengths of the sides of the squares (instead of the "diameter" in the case

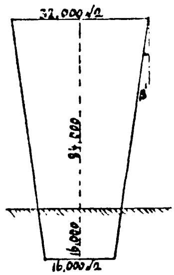


FIG. 19

of a circular section). The distances of the corners from the central axis are $8000 . \sqrt{2}$ and $16,000 . \sqrt{2}$. The slope (β') of the line joining the corners is given by the equation—

$$\left.\begin{array}{r} 16,000 \sqrt{2} \cot \beta' \\ -\ 8,000 \sqrt{2} \cot \beta' \end{array}\right\} = (84,000 + 16,000)$$

$$\therefore \tan \beta' = \frac{8,000 . \sqrt{2}}{100,000} = 0 \cdot 11312. \quad \therefore \beta' = 6^\circ\ 27' \text{ or } 6^\circ \text{ (approx.)}.$$

[2] Al-Biruni, *op. cit.*, p. 249.

the development of *Meru* from the square to the round shape. Perhaps other such intermediate stages are discernible in the variations from the "four-coloured, golden, four-cornered, lofty" *Meru* of the *Matsya* and *Vāyu-purāṇas* to the *octangular* shape given by Savarṇi, the 100 angles assigned to *Meru* by Atri, and 1,000 angles by Bhṛigu.[1] The round shape is definitely stated to have been held by Āryabhatta, the elder. According to Balabhadra, the commentator, "Āryabhatta thinks that it (*Meru*) has no absolute height, but only the height of one *yojana*, and *that it is round, not quadrangular*, the realm of the angels."[2] Along with the change in shape the mountain has also begun to decrease in size. In the *Sūrya-siddhānta*,[3] it is described as protruding on either side of the earth, after passing right through the globe, and pointing in either direction to a pole-star fixed in the middle of the sky. Brahmagupta remarks: "Manifold are the opinions of the people relating to the descriptions of the earth and the religious literature. Some describe this mountain as rising above the surface of the earth to an excessive height. It is situated under the pole, and the stars revolve round its foot, so that the rising and setting depends upon *Meru*. . . . The day of the angels who inhabit *Meru* lasts six months, and their night also six months."[4] *Meru* has warped and shrunk to a point coincident with the pole.

[1] Cf. Wilson's *Viṣṇu Purāṇa*, p. 107.
[2] Al-Biruni, *op. cit.*, p. 243.
[3] Chapter XII, Stanzas 34, 43.
[4] Al-Biruni, *op. cit.*, p. 243

§ 7. The Shape of the Earth—Evolution of the Idea

Parallel to the development of the shape of *Meru* and of the "enclosures," from the square to the circle, is the evolution of the concept of the earth's shape through different stages that can be similarly traced.

(1) The earth was believed to be flat and often "four-cornered," as in Chapter III (§ 6).

(2) In the *Ṛig-Veda* it was described as a "bowl." This is precisely the shape that fits some of the descriptions of the *Meru* cosmology. Given the distance between the

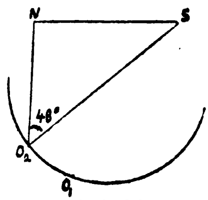


FIG. 20

solstices (N S) (Fig. 20), the locus in the meridian plane of the position of the observer will be the circular arc through N, S containing an angle equal to twice the obliquity of the ecliptic.

(3) A simpler idea, satisfying the same condition for *two* places of observation, is that of the earth sloping down from the second place to the first (see § 5). Coupled with a square base, the earth is conceived as a pyramid, extending to "the four corners of the earth" at the base and rising up to "the roof of the world" and to Mount *Meru* on whose summit lived the gods.

(4) When the square base gives place to a circular one, the earth becomes conical, or, with the angle at the top

also knocked off and rounded, the shape develops into a spherical cap resembling the back of a tortoise (*Kūrma*). This is one of the common Hindu conceptions.[1] Considering that the Tortoise-wheel (*Kūrma-chakra*) was not necessarily circular, and that the Tortoise-altar (*Kūrma-chit*) could be "pointed" as well as circular, we may conclude that the comparisons of the earth to a tortoise-back may have also referred to any pyramid on a polygonal base—an intermediate stage between the square and the circular base.

(5) The spherical cap soon became a full-fledged sphere. The sphericity of the earth was taught by the later astronomers, the first among whom seems to have been the elder Āryabhatta. The priests, however, seem to have still held to the beliefs of the *Vedas* and *Purāṇas*; and Hindu astronomers had to "reconcile" the new ideas with statements in the old *Vedas* and other "revealed" knowledge, before they found general acceptance. Thus Balabhadra, the commentator, says:[2] "the *Āpta-purāṇa-kāras*, i.e. the faithful followers of the *Purāṇas*, say: 'the earth is like the back of a tortoise, it is not round from below.' They are perfectly right, because the earth is in the midst of water, and that which appears above the water has the shape of a tortoise-back."

§ 8. THE COSMOLOGY OF THE TCHEOU-PEI

It is convenient to deal, in this place, with the cosmology of the *Tcheou-pei*, mentioned (in Chapter I) as

[1] Cf. Al-Biruni: *India*, Chapter XXIV.

[2] *Loc. cit.*

similar to the Meru cosmology. The work is one of the oldest Chinese mathematical texts, written at least as early as *c.*1100 B.C., though the portions dealing with the more advanced cosmology are supposed to be of later date, about the second century B.C.; in the latter case, the scheme may have been imported from India by the Buddhist missionaries.[1] As in India, all celestial motion takes place in a number of horizontal circles at definite heights above the flat horizontal earth; the centre of motion is, instead of *Meru*, the Celestial Pole, from which the Pole-star is distinguished and supposed to move in a circle of radius 11,500 *li*. In particular, the sun traces seven circles, during the course of the year: the innermost, of diameter 238,000 *li*, is described at summer solstice; the next five circles, each successively getting wider, are traversed during the next five months; the outermost circle is described at the end of the sixth month, i.e. at winter solstice, and has a diameter of 476,000 *li*. The position of the observer is at a distance of 16,000 *li* from a point on the earth vertically beneath the summer solstice. The visibility of the sun is, as in the *Sūryaprajñapti*, limited by a certain distance from the observer: the sun's light is here stated to extend 167,000 *li* in each direction. This distance is evidently chosen so that on the days of the two equinoxes, when the sun is moving in the fourth circle (diameter = 351,000 *li*), the rays of the sun just reach up to the circle of the Pole-star; on the day of the summer solstice the whole of the circle

[1] *J.A.S.B.*, Vol. 49. Thibaut's article on the *Sūryaprajñapti* contains this description.

is illuminated; and on the day of the winter solstice this circle is never reached by the sun's rays.

Let P, A, S_1, S_7, Σ be the projections on the same horizontal plane, say that of solar motion, of the Pole, the observer (O), the summer solstice, the winter solstice, and the Pole-star respectively (Fig. 21).

$P\Sigma = 11{,}500$ *li.*

$P S_1 = 119{,}000$ *li.*

$P S_7 = 238{,}000$ *li.*

and $A S_1 = 16{,}000$ *li.*

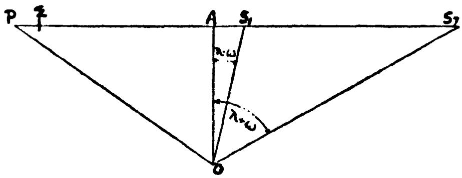


FIG. 21

O A is vertical, and O A ($= x$) is the height of the sun's orbit.

$A O S_1 = \lambda - \omega$

$A O S_7 = \lambda + \omega$

and $A S_7 = A S_1 + S_1 S_7 = 16{,}000 + 119{,}000 = 135{,}000$ *li.*

Assuming the value of ω as 24°, we can calculate the latitude of the place of observation and the height of the Sun, as before.

The latitude is about 35° 18′: this agrees with that of the capitals of Southern China, which were supposed to have fostered astronomical studies in ancient times. But more striking is the resemblance of the figure of the height of the sun (80,000 *li*) to the *Sūryaprajñapti* esti-

mate, namely 800 *yojanas*. Perhaps the two figures were related, though they are not equivalent at the present values of the *yojana* ($= 8\frac{8}{9}$ miles) and the *li* ($= \frac{1}{3}$ mile). Nevertheless, this account shows us how widespread was the scheme of celestial orbits, based on shadow-measurements involving determinations of the obliquity of the ecliptic and of the latitudes of the places, as described in the *Sūryaprajñapti*.

§ 9. The Meru Cosmology—Conclusion

The square shape has thus helped us in solving a problem, important not only to the history of Hindu astronomy, but to the early history of astronomy in general. Besides giving sense to the so-called "priestly nonsense," it has presented us with a beautifully symmetrical picture of the Universe. There is first of all the earth based on a square with a corner towards the south, and shaped like a pyramid, with a number of successive homocentric square terraces rising up to a point (or rather, to a small square); on the top of this is the mount *Meru*, a pyramid widening out as it rises, at a small angle to the vertical; round this lie the orbits of the sun forming homologous squares on a horizontal plane; above the sun's plane is that of the moon with similar orbits. We may imagine that above this were the planes of the different planets at increasing heights, as described in the *Viṣṇu-purāṇa*; if these were also originally square orbits, we should have the original conception of the orbits of the planets as forming successive terraces of a pyramid representing the heavens. Thus once again we

arrive at the suggestion that the Pyramids were perhaps built as models of the heavens (Chapter II). It may be noted that this celestial architecture resembles the essential shape of the "tower" of a Hindu temple—an elongated pyramid.

This shape gradually, but inevitably, went through the process of evolution to the circular shape. Nevertheless, the old ideas still persisted, and were very often mixed up with the later developments. It is to this fact that we must turn in order to understand why the *Sūrya-prajñapti* (or the commentator) takes the trouble of giving the "circumferences" of the orbits as equivalent to $\sqrt{10}$ $(= \pi)$ times the "diameter." This work was written some time about the fifth century B.C.; but the cosmological system described in the work, apart from a few incongruous elements added to it, is certainly of a much earlier date, some time in remote antiquity, when men had not yet begun to regard the circle as the perfect curve, or as providing a scale of angular measurement.

CHAPTER V

CHINESE ASTRONOMY

§ 1. The Archaic Zodiac

The earliest Zodiac of the Chinese, which consisted entirely of figures of "Little Animals," may at first sight create the impression that the figuration of the star-groups preceded and gave rise to the conception of the Zodiac. But closer examination of the uses to which this primitive Zodiac was put, would show that it was rather a scale of *divisions* that could be applied not only for the collection of the ecliptical constellations into suitable groups, but also for such diverse purposes as measuring time-intervals and representing cycles and directions of the horizon. The *Encyclopædia Britannica* (11th Ed., Vol. XXVIII, p. 995) may be quoted as supporting this view:

"The Chinese circle of the 'animals' ellipsis is denominated by Humboldt the 'zodiac of hunters and shepherds,' and he adds that the presence in it of a tiger gives it an exclusively Asiatic character. It appears never to have been designed for astronomical employment. *From the first it served to characterize the divisions of time. The nomenclature not only of the hours of the day and of their minutest intervals was supplied by it, but of the months of the year, and of the years in the oriental sixty-year cycle, and of the days in the 'little circle' of twelve days.*"

The Chinese, like the Egyptians and Babylonians, used

to divide the day into 12 double-hours—no doubt, an application of the scale of 12 divisions.

§ 2. The Great Dial Plate

The divisions of the Zodiac applied equally well to the divisions or the *directions* of the horizon. The starry heavens, says Edkins, were "regarded as a great dial plate of time and destiny," on which heavenly bodies moved forward or backward, slower or more quickly; "the Great Bear was the index which like the pointer of a clock directed every hour the attention of the observer to a division of the horizon."[1] The correlation of the zodiacal divisions and the directions was achieved by observing the tail of the Great Bear: "When the tail of the Bear points to the east (at nightfall) it is spring to all the world. When the tail of the Bear points to the south, it is summer to all the world. When the tail of the Bear points to the west, it is autumn to all the world. When the tail of the Bear points to the north, it is winter to all the world"[2] (Fig. 22). Chalmers gives the following explanation of this statement: "The earth's surface (square, of course) is converted into a dial, and the horizon is divided into 12 parts, marking due north the centre of the first division. In theory the time of observation is 6 P.M. precisely. But it was necessary to wait till the stars were visible. If the tail then pointed due east, it

[1] Edkins: *Ancient Symbolism Among the Chinese*, p. 6.

[2] Cf. "Astronomy of the Ancient Chinese," by the Rev. John Chalmers (James Legge's *Chinese Classics*, Vol. III, pp. 90–104)—quotation from *Hoh-kwantze*.

indicated the vernal equinox; but if it pointed due west, as represented in the figure, it was the autumnal equinox," and so on.

It is easy to notice that the tail stars of the Great Bear pointed to the autumnal equinox (Scorpio) *c.* 3000 B.C.; at nightfall on the vernal equinox the constellation Scorpio was opposite to the sun, i.e. in the east, so that the spring was connected with the eastern direction of the horizon (and with Scorpio); at summer solstice the sun has moved

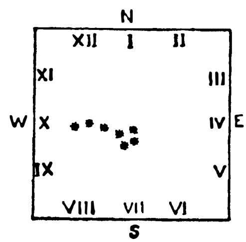


FIG. 22

90° in the counter-clockwise direction from the first position among the stars or relatively to the Great Bear; so that the tail-stars of the Great Bear would at "nightfall" point in a direction which is 90°, counted clockwise, from the initial east, i.e. towards the south; hence the summer was connected with the south. Thus the tail of the Bear moves continuously round the directions of the horizon, in a clockwise direction, helping to establish a connection between these and the divisions of the Zodiac.

§ 3. The Four Divisions

Though the four seasons were correlated with the four directions with the help of the tail of the Great Bear,

it is not clear how they arrived at the *four* seasons or at the *four* directions originally: at least one of the two sets must have been known before they proceeded to determine the second set or correlate the two sets. Unless one believes that these divisions were obtained instinctively, or by the obvious presence of clear-cut groups in the surroundings, one has to concede that at the root of any such grouping lay the cardinal divisions into the four groups like the one that automatically followed the division of the square.

Such a fundamental division is perhaps responsible for the Chinese grouping the zodiacal stars into four monster "constellations" called *Tsing Lung*, the "Azure Dragon," *Heung Woo*, the "Dark Warrior," *Choo Neaou*, the "Red Bird," and *Pih Hoo*, the "White Tiger." These were also regarded as "four large equal spaces" that "included" the twenty-eight *sieou* or mansions and the twelve signs; or as "palaces" assigned to the quarters as well as to the seasons.[1] Thus the Azure Dragon was the spring constellation, in the east, its central sign being Scorpio, and the central *sieou Fang* (= House); the Red Bird belonged to the summer in the south, marking the residence of the Red or Southern Emperor, and consisting of the Quail's Head (Cancer), the Quail's Fire (Leo), and the Quail's Tail (Virgo); the White Tiger was the autumnal constellation placed in the west, and consisting of Aries, Taurus (and Orion), and Gemini; and the last one, the

[1] The positions of the constellations at sunset at the vernal equinox appear to have determined their quarters, E., S., W., N.; they "rise" at sunset of their respective "seasons."

Dark Warrior, represented the winter, in the northern quarter of the sky, and consisted of Aquarius, Capricorn, and Sagittarius.

Similar customs of assigning the quarters of the world to different stellar representatives could be traced in other countries; these stars are found to be nearly the same as the central *sieou* of the Chinese constellations. Thus the Persians[1] had "the Four Royal Stars," "the Four Guardians of Heaven," *Hastorang* in the north, *Vanant* in the south, *Tascheter* in the east, and *Satevis* in the west. The first three of these Flammarion identified with Fomalhaut, Regulus, and Aldebaran, so that the last one *Satevis* was meant for Antares. These four stars probably corresponded to the similar deities of the Hindus, the Four *Lokapālas*, or Guardians of Heaven. They appear to have represented the four monster constellations, as they occupy more or less the central positions of these groups and bear names akin to the bigger groups: thus Antares is the 16th *sieou*, *Sin* (= heart), which, according to Brown, denoted the heart of the Dragon; Regulus was *Niaou* the Bird, representing the big group, the Red Bird; Aldebaran is near the centre of the White Tiger, and this name is often applied to the Pleiades or to Orion.

These four stars, separated by a right ascension of (roughly) six hours from each other, were, as Allen states, "everywhere probably used to mark the solstitial and equinoctial colures, four great circles in the sky, or generally the four quarters of the heavens." We shall

[1] Cf. Allen: *Star-names and their Meanings*, p. 256, etc.

presently see that the solstices and equinoxes were at the *middle* of the seasons in ancient times, instead of at the beginning, as in our usage; this was represented by the square more effectively than by the circle, as each of the four mansions of the cardinal figure could be utilized to denote the seasonal intervals, while the *corners* of the square represented the solstitial and the equinoctial points. The mansions and the corners would, likewise, represent the four mammoth constellations and their central *sieou.*

§ 4. The Arrangement of the *Sieou*

The 28 *sieou* were distributed *equally* among the four monster constellations: the seven divisions of the first (eastern) group begin with the 12th *sieou, Kio* (= Spica), and end with the 18th; the next seven (19–25) belong to the northern (winter) constellation; and so on. The distribution is seen clearly in the following table:

Directions	East	South	West	North
Seasons	Spring	Summer	Autumn	Winter
Monster Constellation	Azure Dragon	Red Bird	White Tiger	Dark Warrior
Signs	Sagittarius, Scorpio, Libra	Virgo, Leo, Cancer	Gemini, Taurus, Aries	Pisces, Aquarius, Capricornus
Sieou (nos.)	18, 17, 16, *15*, 14, 13, 12	11, 10, 9, *8*, 7, 6, 5	4, 3, 2, *1*, 28, 27, 26	25, 24, 23, *22*, 21, 20, 19

Schlegel has attempted to represent the arrangement of the 28 *sieou*, the 12 signs, the hours, and the four divisions, in a diagram (Fig. 23*a*). It shows how the *sieou*, beginning with *Kio* (12th, Spica) as the *first*, fall into the signs in the order 1, 2; 3, 4, 5; 6, 7; 8, 9; 10, 11, 12; 13, 14; 15, 16; 17, 18, 19; 20, 21; 22, 23; 24, 25, 26; 27, 28. Schlegel's figure, however, contains no indication of any principle underlying such a grouping: there is no apparent reason why one arc of a circle must contain 3 *sieou*, while the neighbouring ones contain only 2 *sieou*. On the other hand, by referring them to the square Zodiac, we can very clearly see the law governing the distribution.

In the above series, a sign containing 3 *sieou* is bounded on either side by a sign containing only two. This gives the clue to the method of arranging them: the sign of 3 *sieou* must be the central sign of the quadripartite group, and must therefore occupy the *corner* of the square Zodiac of 12 divisions (Fig. 23*b*). When this square Zodiac is sub-divided into 28 mansions, the corner-sign lends itself to division into three mansions, while the signs on either side yield only two mansions each. This series starts (with *Kio*) at the mid-point of a side (S.E.) of the square, and proceeds in the same (counter-clockwise) direction as the signs Aries, Taurus, etc. The series *naturally* falls into 4 groups, each group containing 3 signs and 7 *sieou*, of which the central *sieou* occupies the prominent position at the corner.

These central *sieou* are *Mao* (the Pleiades) in the West, *Sing* (stars in Hydra) in the South, *Fang* (β Scorpionis) in the East, and *Hiu* (stars in Aquarius) in the North.

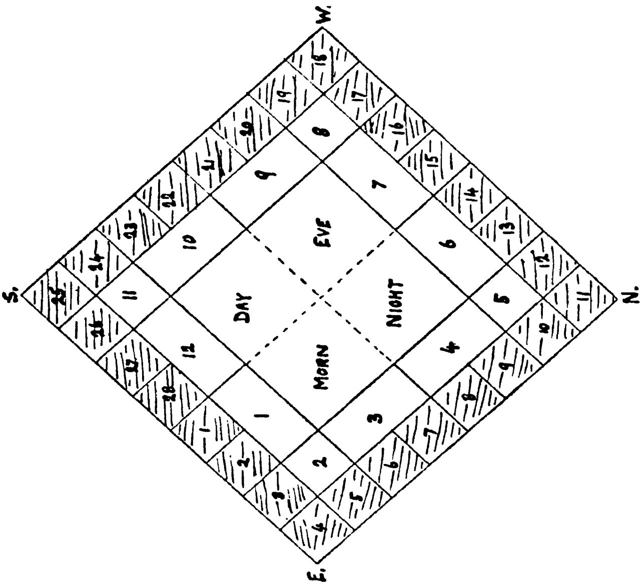


FIG. 23(b)

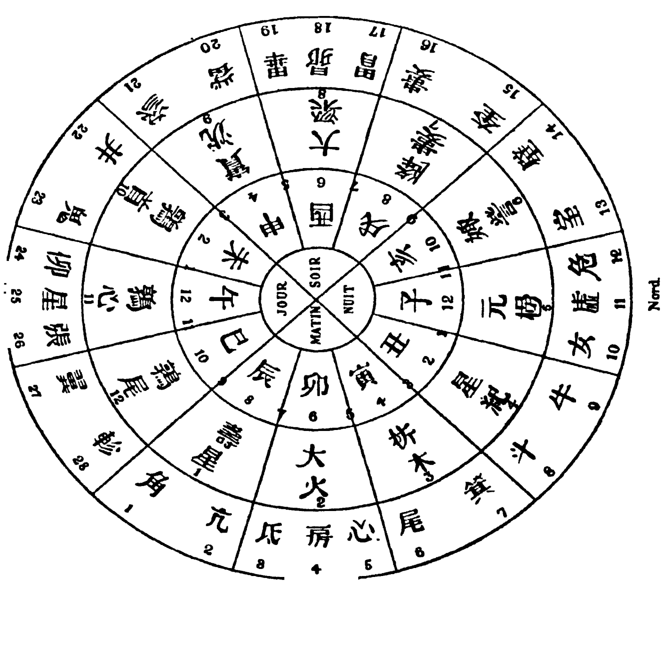


FIG. 23 (a)

According to Biot, *Mao* began the early Chinese lists of *sieou*, just as *Kṛittikās* in the Vedic lists, as the Pleiades were at the vernal equinox *c.* 2,300 B.C. This constellation and *Hiu* are among the four *sieou* which are declared to coincide with the solstices and the equinoxes, in the famous exhortation of Yao to his astronomers to go forth to the four extremities of the earth, and watch the four corresponding positions of the sun.[1] Our square figure shows to advantage how the "corners" of the square could represent the four extremities of the earth and the four directions as well as the solstices and equinoxes; and at the same time the star at each corner could represent the four monster constellations which are equated with the four seasons.

The symmetry of the distribution—not to speak of the additional explanation offered of the four mammoth groups of the Chinese—fits in well with the theory here developed regarding the origin of the divisions of the Zodiac. Whatever the particular constellations may be that were chosen to represent the divisions, and whatever the names given to them, the divisions of the Zodiac into 4, 12, and 28 parts appear to have been of kindred origin, and probably simultaneously evolved, or, if they did

[1] At a later epoch (*c.* 1100 B.C.) the solstices and equinoxes would have been represented by the four neighbouring *sieou* to the east, viz. *Ti*, *Nu*, *Wei*, and *Leu*. These were the four *sieou* that Biot supposed were added by Cheu-Kong (in 1100 B.C.) to a system of 24 *sieou*; but, as Whitney controverted, there is no tradition or documentary evidence for such an addition, while on the other hand, these four bright stars are entirely in place in a system of 28. Perhaps there was only an *alteration* of the *sieou* in the corner, because of the precessional shift.

originate at different times, the Zodiac of 28 divisions was derived from that of 12, and not vice versa.

§ 5. The 28 Animals

The immediate derivation of 28 divisions from the Zodiac of 12 divisions is seen by the inspection of a list of 28 animals that the Chinese used as an "astrological Zodiac." These are different from the 28 *sieou*, and proceed in the same direction as the "Rat-zodiac," i.e. from east to west—whereas the 28 *sieou* followed the direction of the 12 signs Aries, Taurus, etc. Further, the animals of the Rat-zodiac are all found among these 28 animals, arranged in a particular order.

Schlegel gives these as follows:[1]

1.	Kiao	Le Boa	15.	Lang	Le Loup
2.	Loung	Le *Dragon*	16.	Kao	Le *Chien*
3.	Ho	Le Blaireau	17.	Tchi	Le Faisan
4.	T'ou	Le *Lièvre*	18.	Ki	Le *Coq*
5.	Hou	Le Renard	19.	Wou	La Corneille
6.	Hou	Le *Tigre*	20.	Hao	Le *Singe* (grand)
7.	P'ao	Le Léopard	21.	Youen	Le Singe (petit)
8.	Hiai	La Licorne	22.	Han	Le Chien Sauvage
9.	Noiu	Le *Boeuf*	23.	Yang	Le *Bélier*
10.	Fou	La Chauve-Souris	24.	Tchang	Le Cerf (grand)
11.	Chou	Le *Rat*	25.	Ma	Le *Cheval*
12.	Yen	L'Hirondelle	26.	Lou	Le Cerf (petit)
13.	Tchou	Le *Porc*	27.	Chie	Le *Serpent*
14.	Yu	Le Pangolin	28.	Yin	Le Ver-de-terre

It is easily seen that the 28 animals fall into 12 groups of two or three, each group containing one animal of the Rat-zodiac and one or two kindred animals. Thus the

[1] Cf. *Uranographie Chinoise*, p. 258. The bracketing is mine.

Boa and the Dragon are evidently derived from the sign of the *Dragon*; the Badger and the Fox are included with the *Hare*; the Leopard resembles the Tiger; the Unicorn and the Bull are derived from the *Ox*; the Bat and the Swallow are connected with the *Rat*; the *Pig* and the Ant-eater are classed together, probably because of their pointed snouts; the Wolf was a variant of the *Dog*; the Pheasant and the Crow are of the same kind as the *Cock*; the *Ape* is sub-divided into two sizes; the Wild-Dog is as fierce as the butting *Ram*; to the *Horse* were added two kinds of Deer, equally domesticable creatures; the *Serpent* gave rise to the sub-division of the Earth-worm, a creeping thing, though insignificant compared with its neighbours, the Serpent and the Boa. Thus the 28 animals are immediate derivatives from the 12 animals of the Rat-zodiac. Further, it will be seen that each group of the 12 divisions contains 2, 3, 2; 2, 3, 2; 2, 3, 2; 2, 3, 2 animals respectively. This is exactly the order in which the *sieou* were distributed among the signs, and was therefore capable of representation by the square divisions. Taking into consideration the archaic age of the Rat-zodiac and the picture-theory of its origin, one can consistently conclude that the square of 12 divisions was divided into a border of 28 squares, and that the 12 picture-signs placed in the small squares were increased to 28, by the addition of similar, but slightly different, pictures of animals, to represent the smaller intervals; these pictures were again, as in the case of the signs, later transferred to the starry heavens.

§ 6. Division in a Chinese Calendar

The square Zodiac, and probably its division into 28 mansions, appears in a Chinese manuscript in the British Museum.[1] It is entitled "A Calendar for the year A.D. 978. With a drawing of the God of the Great Year Star (the planet Jupiter) surrounded by deities representing the

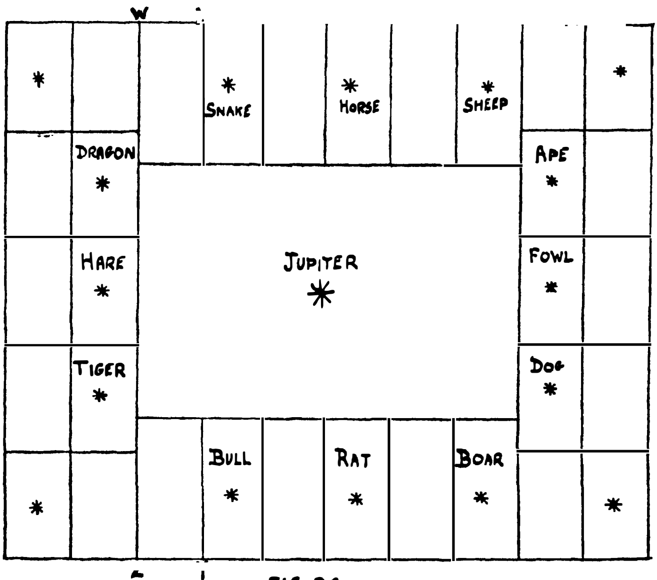


FIG. 24

12 months and the guardian kings of the four quarters of space."

The spaces marked * have pictures of gods. The headgears of the gods are decorated with images of animals, which I have identified with the help of a list of Chinese animals of the Rat-zodiac, and named as in the figure.

[1] S. 612. Fig. 24.

The roll is cut and joined along X Y; the width of the roll is about the same as that of the drawing; and its length extends in the direction of W X and Y Z.

The "human" figures are evidently called gods of the months, as the months and the zodiacal divisions were represented by the same symbols. The roll contains more divisions than are necessary to "house" the entire set of gods mentioned in the title. The gods of the months are pictured in more or less alternate divisions; there is, roughly speaking, one vacant division accompanying the god of a month; this is rather suggestive of an intended division into 28 mansions; and the general plan, a big rectangle in the centre surrounded by a number of smaller rectangular mansions, is not very different from the scheme of 28 divisions derived from the 12 squares. Probably the manuscript gives an imperfect representation of such a scheme; the imperfection may be due either to loss of knowledge of the original plan, or else to the limitations of space in the roll. In support of the latter reason, it may be noted that the width of the roll being limited and its length unlimited, the scribe would place the vacant divisions on the right or the left of the signs, instead of on all the four sides; he could do this with better symmetrical effect when he had to add the guardians of the 4 quarters to the set.

In all, there are 32 divisions, excluding the central rectangle reserved for the "King," Jupiter. Four in the corners contain the guardians of the four directions—another instance of the "four quarters of space" connected with the *corners* of the rectangle. The other 28

are exactly the mansions suited to represent the 28 *sieou*; the picture of the guardian of the month was drawn in any of the 2 or 3 *sieou* included in the sign, and the other mansions were left vacant. Thus it is quite possible that the diagram was derived from the original scale of 28 divisions; a similar alteration of the original divisions so as to connect with 32 deities was noticed in Hindu astronomy (Chapter III).

§ 7. THE DIVISIONS OF THE EARTH—THE *SHU-KING*

The second mode of obtaining the different divisions, described in the second chapter, acquires abundant support from the manner in which the Emperor Yao is related to have divided his dominions. The story is narrated in the *Shu-King*, Part III, Book I, part ii, stanzas 14–23; Legge, commenting on the story, gives certain diagrams which are exactly the first five of the diagrams obtained by the "method of borders."

Thus stanza 18 of the *Shu-King* states: "Five hundred *le* (= *li*) constituted the Imperial domain." Legge explains that the 500 *le* are understood to extend in all directions, north, south, east, and west from the capital, so as to form a square of side 1,000 *le*, which he represents by the diagram (Fig. 25 (*a*)). This is the same as the "cardinal figure" (Chapter II, § 1) representing the quadripartition of the enclosure.

The next stanza has it that "Five hundred *le beyond* constituted the Domain of the Nobles. . . ." Legge adds: "On the imperial dominion this extended 500 *le* in every

direction"; and he gives the figure (*b*) to represent it. This is our scale of 12 divisions. Again, the text, stanza 20: "Five hundred *le still beyond* formed the Peace-securing Domain," is explained as before, and represented by the diagram (*c*). This gives a border of 20 divisions.

Fourthly, the text "Five hundred *le* remoter still constituted the Domain of Restraint," is explained to constitute a region represented by the diagram (*d*). The border consists of *28* divisions, i.e. the same as the "Lunar Zodiac."

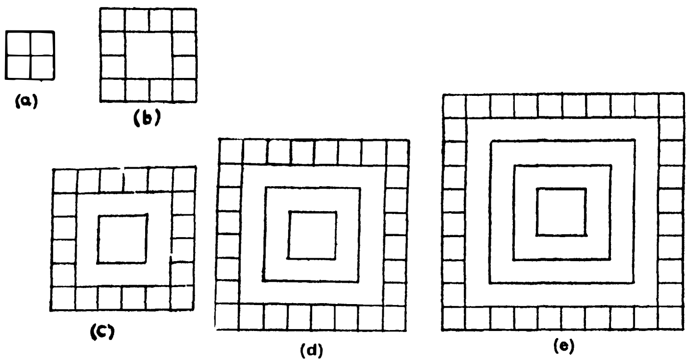


FIG. 25

Lastly, "Five hundred *le*, the *most remote*, constituted the Wild Domain." This is represented by the diagram (*e*); the border consists of 36 divisions, such as we found in the series obtained by "the method of borders" (Chapter II, § 2).

Legge says: "the Five *Fuh* constituted what we may call the China Proper of Yao's time." But he himself mentions the difficulties in the way of such a conception, though he gives plausible explanations of these difficul-

ties. Thus the area of China could not have been as much as the square of 5,000 *le* (= 1,700 miles), unless the value of *le* had been very much smaller. The capital of Yao was in K'e-chow, the most northern province of China, so that his domain could not have been a square at the *centre* of his whole dominion. And thirdly, under the Chow dynasty, the *Fuh* are increased to *ten* (9 borders round the central square) so that the area of the country has to be a square of 10,000 *le*—which is impossible. The only explanation is that the incident refers to the division of the *Earth*, which the Chinese regarded as a square, into a number of rectangular zones; the distance of the outermost region perhaps represented the extent of the territories on the earth known to, or ruled by, the Emperor. Or it may be just a symbolical division of the surrounding space, not necessarily terrestrial, just as the "Emperor" or the "Councillors" or the "Palaces" represented star-groups or zodiacal divisions. In any case, the account furnishes complete evidence of the *actual* use of the method of bordering squares in ancient times.

The view here given, that the above description refers to the divisions of the *Earth*, is very strongly supported by the fact that the Chinese represented the Earth itself by the symbol ⊞,[1] which is the central region of the Emperor's dominion (the first of the figures in the previous section). It is the "cardinal figure" from which the successive scales were derived (Chapter II, § 1), and was no doubt utilized by the Chinese to represent the prime

[1] Cf. D'Alviella: *Migration of Symbols.*

division of the enclosure into four quarters. The chief "enclosure" that concerned the primitive peoples was the horizon, which bounded the earth and defined its shape: the symbol was therefore considered appropriate for the earth with its four quarters.

CHAPTER VI

BABYLONIAN ASTRONOMY

§ 1. THE DIVISIONS OF THE ZODIAC

As in India and China, so in Babylonia there was not merely one "Solar Zodiac" or "Lunar Zodiac," as hitherto supposed, but there were a number of sets of divisions of the Zodiac. In a Euphratean star-list, classified by Brown[1] into three groups, the Northern constellations, the central or zodiacal constellations, and the Southern constellations, the central group alone contains 74 members. These are obtained by collecting the stars near the Zodiac under different groups in different combinations. Thus the stars constituting the constellation Aries are included in 5 groups.

These different ways of grouping the zodiacal stars probably arose out of the necessity of obtaining concrete representatives for the different series of mansions into which any enclosure was directly divided. That different scales were fitted to the ecliptic so as to divide its stars *simultaneously* into different groups may be gathered from Brown's statement: "It must be remembered that the solar zodiac was, if I may so express it, placed upon the lunar zodiac, and covered the same space in Uranography. Hence the reappearance, in the derived lunar scheme, of names drawn from the original solar scheme."[2]

[1] *Primitive Constellations*, Vol. II, Chapter XV.
[2] "Euphratean Stellar Researches," Part V (*P.S.B.A.*, December 1895), p. 289.

The reason for such a "superposition" appears clearly from my derivation of the scale of 28 parts immediately from the scale of 12 squares.

Further, the view that the Zodiac was primarily a set of *divisions* which formed the basis of the constellations chosen later to represent them may be illustrated by two or three Babylonian sets of 12 members, which were not necessarily *dependent* on the constellations. First of all there were the 12 Akkadian months, which were merely the 12 equal parts of the annual cycle (cf. Vedic division). Sayce has shown[1] that these are connected closely with the constellations Aries, Taurus, etc., but it is at least as likely that the star-groups were chosen later and named after the months in which the sun stayed with them, as that the reverse happened. The former alternative is supported by the Akkadian habit of connecting the months with 12 *solar* deities, like the *Ādityas* of the *Vedas* (see Chapter III, § 2); perhaps these were, to begin with, only 12 *forms* of the same Sun-god, assumed during the 12 parts of the year, which later developed into 12 *stellar* figures—just as the Sun-god (*Merodach*) himself was later reduplicated in other "stars" like Jupiter or Mercury.[2] Moreover, it may be noticed that the Babylonian Epic of Creation, whose "selection and arrangement" has attracted much attention and is supposed to "have been determined by astronomical reasons," consists of 12 tablets which relate the adventures of the Solar hero *Gisdhubar* (*Gilgamesh*) during the 12 stages of the

[1] *Astronomy and Astrology of the Babylonians*, pp. 162–6.
[2] *Ibid.*, p. 166.

sun's journey;[1] the one-to-one correspondence strictly maintained between the tablets and the stages of the sun's journey, or the months, shows the importance attached to the scale of 12 parts. Finally, the sun's daily path was, like his annual circuit, divided into 12 parts giving 12 double-hours called *kasbu*.

All these were therefore based on *divisions* of the ecliptic, or of some enclosure. The ecliptic was indeed called an "enclosure," *kesda*; Brown derives this from *Khas*, "to cut," or "division," etc.[2]—perhaps this shows the close association between the enclosure and its graduations. There are several instances of such association to be seen in the use of the same name or the assignment of the same deity to a division as well as to the whole of the ecliptic. Thus the "Yoke-of-the-Enclosure" primarily denoted the ecliptic, but was also the name of one of the lunar mansions given by Brown; *the kakkab Lugal* (the Asterism of the Mighty Man) was ruled by the god *Merodach*, a Solar deity, naturally connected with the whole ecliptic; and the *kakkab Sakh*[3] (the Asterism of Prosperity) was governed by *Da-mu*, the god of the Sky-Furrow, i.e. the Ecliptic, this "circle" being also called *Pidnu-sha-shame*, the "Furrow of Heaven." The last asterism was also governed by *Anu*, one of the chief Babylonian deities reigning over the directions. Perhaps one might imagine the "Furrow of Heaven" to have been square-shaped, considering that the plough used to

[1] *Astronomy and Astrology of the Babylonians*, pp. 164–5.
[2] *Primitive Constellations*, Vol. II, Chapter XI. Tablet of Thirty Stars. Line X.
[3] *Ibid.*, Line XVII.

ply round and round plots of land which, according to Herodotus, were originally squares; we shall presently see that the primitive enclosure was symbolized by a square (§ 7).

§ 2. The 36 Decans

Though the scale of 28 divisions has not yet been found for certain to have been used by the Babylonians, they appear to have known the scale of 36 divisions—which is the next smaller scale in the series of "borders." The tablet from which Epping and Strassmaier gave their original list of 28 star-groups was soon found to contain 33 members which, together with 3 members supposed to be missing, might have formed originally a set of 36 stars.[1] Brown adds the comment that *36* is "an artificial number which, I think, is clearly connected with the thirty-six names of *Ea*, considered as a zodiacal power, whether lunar or otherwise. These 36 stars supplied the origin of the theory of the Decans, or 36 Genii, who ruled the Zodiac, and whose later Graeco-Egyptian names are given by Julius Firmicus. Decanal 'theology' was a secret and important part of ancient astro-religious belief."[2] It is not necessary to attribute the origin of the Decans to these *stars* as such. On the other hand, if we compare the Akkadian use of 36 names of *Êa* with that of the 12 names of *Merodach* in the 12 months (see last section), and with the 12 *Âdityas* and 108

[1] Chapter I, § 8 *supra*. Though Hommel tried to reduce the system to 28, Brown leaves them as an original set.

[2] *Primitive Constellations*, Vol. I, p. 341.

names of the sun[1] of their sun-worshipping brethren on the banks of the Indus and the Ganges, we might infer that there was primarily an enclosure divided into 36 parts; these could be called by "the 36 names of *Êa*, considered as a zodiacal power"; or they could have 36 Genii called Decans to guard over them, as in the case of the *Nakshatras*; and they could further be represented in *concrete* form by 36 star-groups chosen later.

There is some confusion in the explanation of their name. Miss Clerke writes of them: "The Chaldeans chose

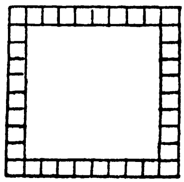


FIG 26

three stars in each sign to be the 'councillor-gods' of the planets. These were called by the Greeks 'Decans,' because ten degrees of the ecliptic and ten days of the year were presided over by each." This explanation seems to be due to Diodorus,[2] who relates how each of the "councillor-gods" remains 10 days in the same place; but these councillor-gods are only 30 and could not have been the same as the 36 Decans. "And under the orbit of these (the planets) they say that thirty stars which they denominate 'Divinities of the Council' have been marshalled." These 30 stars Brown supposed to be the same

[1] Chapter III, § 2, etc.

[2] ii. 301.

as the stars of his Lunar Zodiac, which are different from his "36 Babylonian Ecliptic Constellations."[1]

Perhaps an alternative, if not a better, explanation is offered by our diagram representing the number 36 (Fig. 26). Each edge of this square scale contains exactly *ten* divisions; this fact might have given the name Decans (*Decania*) to the "college." The division of the outer edge into decimal parts might have likewise led to the system being known by the alternative name *Decimae*.[2]

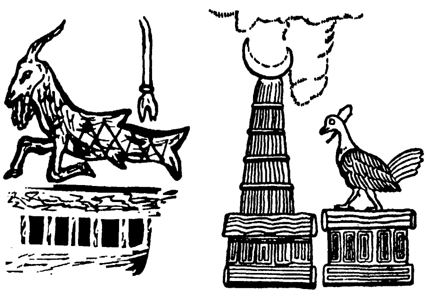
§ 3. The Sexagesimal System

The characteristic use of such scales to divide the horizon or ecliptic, and locate different deities in the different directions, is perhaps indicated by the Chaldean application of the scale of *60* to their "Councillor-Gods." This habit is described by Maspero in a passage which may be quoted more fully, as it shows, besides, the important part played by *numbers* as the foundation of the ancient Universe:

"It is well known that Orientals display a great respect for numbers, and attribute to them an almost irresistible power; we can thus understand how it was that the Chaldeans applied them to designate their divine masters, and we may calculate from these numbers the estimates in which these masters were held. The goddesses had no value in their celestial arithmetic, *Ishtar* excepted. The numbers of the two triads were arranged in a descending scale, *Anu* taking the highest place; *the*

[1] *Op. cit.*, Vol. II, Chapter XI; also see Chapter IX.
[2] Cf. Allen: *Star-names*, p. 9, for a short account of the Decans.

scale was considered to consist of a soss of sixty units in length, and each of the deities who followed *Anu* was placed *ten* of these units below his predecessor, *Bel* at 50 units, *Êa* at 40, *Sin* at 30, *Shamash* at 20, *Rammon* at 10 or 6. The gods of the planets were not arranged in a regular series like those of the triads, but the numbers attached to them expressed their proportionate influence on terrestrial affairs—to *Ninib* was assigned the



(a) (b)

FIG. 27

same number as had been given to *Bel*, 50, to *Merodach* perhaps 25, to *Ishtar* 15, to *Nergal* 12, and to *Nebo* 10."[1]

It must be remembered that many of these deities, especially the two triads, were associated with the Zodiac and its divisions: *Anu, Bel,* and *Êa* are often believed to be related to Taurus, Scorpio, and the neighbouring constellations; *Rammon* is figured with the horns of the Ram and was associated with Aries; and so on. On the same system that these gods were placed at distances of ten units, the 12 zodiacal constellations must each be assigned five units. These five units are perhaps intended to be

[1] *The Dawn of Civilization,* pp. 672–4.

represented by small scales of five squares attached to constellational figures in many Babylonian relics. Thus Landseer, in his *Sabaean Researches*,[1] gives an impression from a signet containing a goat-fish with a "mechanical figure" (Fig. 27 (*a*)) underneath which, he declares, "is an early and rude attempt to shew, by means of measured degrees, the portion of the zodiac which was occupied by the stars of Capricorn. If I mistake not, the most ancient division of the armillary zones of the sphere—but more especially of the ecliptic—was into sixty parts, which would leave five for each of the signs." I may draw attention to the use of small *squares* to represent the units of the scale—as though they were derived by division of the square. A similar figure, taken from Layard's *Nineveh and Babylon*, is seen in (*b*).

§ 4. The Sanctity of the Corners

That the primitive enclosure was square-shaped could be understood from the special sanctity attached to the "four corners" in most ancient countries. In Babylonia this conception "took the form of making a deposit of inscriptions and images under the corner or corners of a temple, palace, or tower."[2] The contents of the deposits indicate that they were remnants of sacrifices; they include statuettes of human figures and of animals which were perhaps actually, or else symbolically, sacrificed. One of the cylinder inscriptions presents the declaration of Sargon of Assyria (722–705 B.C.): "To the brick-god,

[1] 1823, p. 290.

[2] *E.R.E.*, Vol. IV, p. 119 *et seq.*

the Lord of the brick-foundations, and to the chief architect, *Bel,* I offered a sacrificial lamb, I poured a libation, I raised the lifting up of hands."[1]

The "Brick-god" was perhaps the *Bull,* which was called *Temennu,* the Foundation, i.e. of the year, the next month being *Mun-ga,* the Making of Bricks;[2] thus the "Brick-god" was related to the vernal equinox. In the opposite part of the sky was the *Kakkab Entenamasluv,* the Asterism Lord-of-the-Foundation of Brickwork (the 22nd lunar mansion of Brown) made up of 20 Librae and the stars adjoining it.[3] Thus the equinoxes were connected with the corners of the enclosure, as in India and China. Sacrifices were probably performed, as in Vedic India, to symbolize the end of the annual cycle at an equinox or a solstice, and the remnants of the sacrifices deposited at the corners of the buildings which corresponded to these four epochs.

§ 5. Figures on Boundary-Stones

I have been able to collect some evidence for the square shape and arrangement in connection with the zodiacal divisions from the Assyrian galleries of the British Museum. On a number of boundary stones of *c.* 1200–1100 B.C. are shown pictures of the zodiacal constellations Scorpion, Archer, etc. These are usually on one *face* or more of these stones; probably the stones were them-

[1] *Loc. cit.*

[2] Sayce: "Astronomy and Astrology of the Babylonians" (*Trans. S.B.A.*, Vol. III).

[3] Cf. *Primitive Constellations,* Vol. II, Chapter XI,

selves intended to be of rectangular cross-section; the rough-hewn rectangular blocks with their tops slightly rounded off, might have assumed their present crude shapes through the wear and tear of the exposed parts.

The constellation-figures are all arranged in layers, one

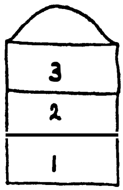


FIG. 28

above another (Fig. 28). Epping and Strassmaier have reproduced the figures on one boundary stone, in the *Astronomisches aus Babylon*; but they have further arranged these around a *circle*, or rather along different circles (Fig. 29). I am not certain how far this procedure

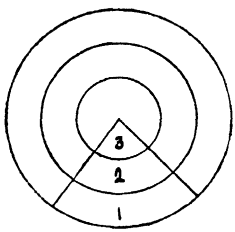


FIG. 29

is warranted by their knowledge of the cuneiform texts, but it is transparent that such an arrangement has led to a distortion of the original figures: their lengths are out of proportion. For the figures in the lowest layer of the stone are placed in the outermost parts of the circle, and the topmost figures of the stone in the central region

of the circle, thereby lengthening the former figures and shortening the latter. The arrangement is to be attributed to our *prejudices* regarding the shape of the Zodiac as circular; the thought of the possible existence of a "square Zodiac" might have discouraged such a procedure.

Another point which has escaped notice is that the animals (deer or goat-fish, etc.) seem to be "coming out" of the *Mansions* (?). That is the impression formed by an observation of the manner in which these animals are drawn with a square enclosure, which is divided into a

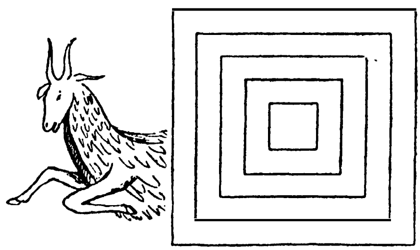


FIG. 30

number of concentric square zones, usually five (Fig. 30). The square enclosure is appropriate to the "house" which was the usual designation of the signs in ancient India and China, and even the divisions of the lunar Zodiac were called "mansions"; these five inter-spaces probably represented sub-divisions of the Zodiac. Some of these houses are elongated, but still the idea is there—the idea of 5 inter-spaces. These might have represented the "bordering" arrangement (see Chapter II, § 2). The series of 5 borders is 4, 12, 20, 28, and 36; the outermost corridor could have been used to denote the number 36 and locate the 36 Decans, for instance. This is supported by another

feature of these figures, which has likewise escaped comment. Above each of the square enclosures or mansions can be seen a small scale of equal divisions. This might easily be passed by as mere decorative work, but careful observation will show that there are usually *ten* divisions; sometimes there are twelve, but the two at the ends are much smaller, and may be ignored as being merely the ends of the scale. These ten divisions are obviously those of the outer edge of the scale of 36 mansions, which, I suggested (see § 2) gave them the name *Decimae*.[1]

Further, in a dark corner of a boundary stone, I noticed two patterns: (i) just the mansion with the five corridors or borders, *without* any animal attached to it; and (ii) a square pattern like a piece of our graph paper. The significance of these patterns is not evident till one refers to the original method of division: these will now appear to be the sub-strata of their original Zodiacs.

The rectangular enclosures are found on several boundary-stones, as also on cylinders and seals. For instance, on some cylinders[2] are illustrations containing "rectangular objects" along with other symbols which are known to be related to astronomical concepts, such as the winged sacred disk of the Assyrians, the Lion, the Gazelle, the Dog, the Flock, and the Tree with branches.[3] Side by side with a person holding a vase slightly tipped (Aquarius?) is one kneeling and "presenting a square object with indications of character upon it"; and in some cases "the

[1] The number of corridors sometimes increases to six and sometimes to seven.

[2] Cf. *B.O.R.*, Vol. IV, No. XI (October 1890), pp. 241–5.

[3] See below, § 7.

square object is a square arrangement of rounded dots." The *number* of these dots is not clear: in two figures given they appear to be *twelve*, but there might have been more, as the writer says that he first saw only seven dots, but later noticed several more in the impression. Besides these, there is a gridiron-shaped object, "which is the gate of the enclosure into which the flock is being led." These may be imagined to be representations of the divisions of the Zodiac, the "flock" being the usual name for the zodiacal stars.

§ 6. A Chequer-Board from Ur

The form of arrangement of the zodiacal scale is perhaps embodied in a "chequer-board" of *c.* 3500 B.C. discovered at Ur of the Chaldees. This board is described in a recent article in *Antiquity*[1] entitled "The Lion and the Unicorn." There are 16 squares on the board, with *12* marked round the margin, exactly as in the square Zodiac of 12 signs. Whether it *actually* represented their original Zodiac or not can only be decided from a consideration of the relation of the board to astronomical notions.

On the squares of the board are displayed several *motifs*, symbolic or decorative, among which one is a picture of the Lion and the Unicorn in opposition. The writer traces the appearance of this picture from the present British heraldry right back to 3500 B.C. The reason for the persistence of this picture is no doubt the important position held at the time of its origin by

[1] December 1930, pp. 425–37; article by Cyril G. E. Bunt.

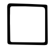
the Lion and the Bull—the Unicorn being perhaps only the Bull drawn in profile, and often found replaced by the Bull. These two signs marked the summer solstice and the vernal equinox during the fourth and third millennia B.C., and probably the onslaught of summer or "the triumph of Summer over Spring" was symbolized by the picture of the Lion attacking the Bull or the Lion devouring the Bull. Other symbols often accompanying the Lion and the Unicorn are of similar astronomical origin. Thus the pine-cone-fruit of the Babylonian Tree of Life was a symbol of Cybele, who with her consort Attis symbolized mother Earth and her fruitfulness and was worshipped at the vernal equinox; it was also associated with the cult of *Mitra*, who was identified with *Shamash*, the Sun-god, by the Chaldeans, and with Helios by the Greeks of Asia Minor.

It may be objected that the square board in question was merely a chess-board. But even chess appears to have been astronomical in its origin (see below, Chapter VIII). One of the illustrations in the article cited shows the Lion and the Unicorn seated on either side of a table, apparently playing a game of chess; the side view of the board with *eight* divisions of the edge (and some pawns) is noticeable. With the board from Ur have been found two sets of 7 pieces (of chess?); these might have represented the seven planets which were connected with chess in India and China (see below, Chapter VIII).

If the margin of 12 squares round the edges of the board represented the zodiacal divisions, the pictures of the Lion and the Unicorn, etc., placed in these squares

would throw additional light on the "picture-theory" of the origin of the zodiacal constellations.

§ 7. Babylonian Symbolism

The Babylonians appear to have used the symbol  to denote any *enclosure* originally associated with other ideas. Lacouperie[1] traces this to the primitive *Hal*  symbol, which pictorially represents an enclosure—the "modern" *Hal* symbol being . It is now easy for us to see how fully the symbol stood for, and perhaps sprang from, the idea of the square enclosure. The symbol was later "applied to heaven, *Zikum*; in Assyrian, *samu*"; probably as an intermediate stage it was applied to the ecliptic which they called "the Enclosure" or "Furrow of Heaven" (see § 1).

The primitive symbol for the "enclosure" was also applied to *Apsu*, the Deep, or "the subterranean waters of the Deep." From this Deep at the base of the world rose the "World-Tree" of the Babylonians—a common subject for artistic representation like their Pine Tree or their "Tree of Life." Its central position with regard to the world-system, connected with the zodiacal enclosure and its divisions (months) may be understood from this rather mysterious passage:

(Its roots) "stretched towards the deep. . . . Its seat was the (central) place of the earth. Its foliage (summit) was the couch of *Zikum* the (primeval) mother. . . . (There is the home) of the mighty mother who passes across the

[1] *B.O.R.*, Vol. II, p. 258.

sky. In the midst of it was *Tammuz*. (There is the shrine?) of the two (gods)."[1]

Similar central posts are found in various ancient cosmic schemes.[2] I shall confine myself to drawing attention to the *Jambu-tree* that stood on a (slightly southern) slope of *Mount Meru*, at the centre of the earth, and thereby gave its name to the earth (*Jambu-dvīpa*). Thus the symbol might have originally denoted the primitive cosmic scheme raised on a square base—the earth or the Great Deep—around a central axis like the *Meru* Mountain.

§ 8. The Ziggurats

The early conception of the Universe seems to have influenced the erection of the famous *Ziggurats* of Babylon. Maspero declares that these "temples were miniature reproductions of the arrangement of the Universe. The 'ziggurat' represented in its form the mountain of the world"[3] (see Frontispiece). Sayce informs us that "The Ziggurat (temple tower) of Nabu at Barsipki was called the 'House of the Seven Bonds of Heaven and Earth,'

[1] *B.O.R.*, pp. 218 *et seq.* Note that *Zikum* was the Zodiac or the enclosure—cf. Vedic mother *Aditi*. *Tammuz* was the fourth month (crab); "the two gods" are the Twins; these two signs are in the "middle" of a side of the square, when the *Bull* is at a corner.

[2] Cf. *B.O.R.*, *loc. cit.* "The *Khanbe* of the *Airanya-Vaedja*, begirt with the starry girdle of the Iranians; the world-pillar of the *Ṛig-Veda*, the star-bearing *aśvat-tha* of the Hindus . . .; the winged oak of the Phoenicians, as described by Pherecydes; the *yggdrasil* of Norse mythology, the *Irmensil* of the ancient Saxons. . . ."

[3] *Op. cit.*, p. 674; also the halls in front of the temple represented "the extent of the accessible world."

and was in seven stages severally painted with the different planetary colours."[1] Brown adds that "these seven planetary bonds combine in forming the bond or yoke of the ecliptic; they make the zodiac, solar and lunar."[2] These buildings were usually surmounted by altars which were mostly of a rectangular shape. These were also related to those zodiacal divisions which we have shown (see § 4) to be connected with the *corners* of the buildings. Another instance of such connection may be seen in the belief that some of the altars were adorned with "horns": "Josephus says of the altar of Herod's temple that 'it had corners like horns,' suggesting that the term was figuratively applied to some ornamentation which surmounted the corners," for "no horns appear upon any Semitic altar as yet discovered."[3] These horns are regarded by some scholars as the "horns of the ox" belonging to the age of bull-worship; this worship was, as I have stated before, inspired by the *Bull* of the Zodiac, which coincided with the vernal equinox, believed to be located at a *corner* of the square, where the horns were accordingly supposed to be placed. Again, "the quadrilateral shape of the Ziggurats, with the four corners towards the four cardinal points, symbolized the four quarters over which the Babylonian kings held dominion."[4]

The temples were called "mountain-houses"; one of the reasons being that the Babylonians wanted a "high place" in which to install their gods, a city and a tower

[1] *Religions of Ancient Egypt and Babylonia*, p. 115.
[2] *Primitive Constellations*, Vol. II, p. 104.
[3] Cf. *E.R.E.*, Vol. I, pp. 351–4.
[4] *E.R.E.*, Vol. XII, p. 148.

that should reach up to heaven, and built these huge monuments. But the name "mountain-house," *E-kur*, was earlier applied to the Earth, which was supposed to be a huge mountain reaching up to heaven.[1] "Later they began to identify one particular part of the earth—a mountain peak preferably—as the dwelling of the god, so that the temples which were built later were known as 'mountain-houses.' The height of the temple thus symbolized the mountain which had formed the original home of the deity."[2] Now, if we pay attention to the shape of these Ziggurats, we shall find that they were stepped pyramids with three or four or more stories and the corners pointing to the cardinal directions; and we can deduce that the shape of the Earth, which appears to have served as a model for these temples, was a *terraced pyramid* with its corners pointing to the South, West, North, and East. This was the form arrived at in connection with the astronomical observations in India.[3]

[1] Cf. Jensen: *op. cit.*, pp. 185–95.

[2] *E.R.E.*, Vol. XII, p. 147.

[3] See Chapter IV.

CHAPTER VII

GLEANINGS FROM OTHER COUNTRIES

EGYPT

§ 1. Egyptian Cosmologies

Among the diverse cosmological beliefs held by the ancient Egyptians there is one system[1] that directly supports the theory of the Square Universe. It has been generally known for a long time that they regarded the Universe as a rectangular box, with the longer sides extending in the direction North to South. We may assume that at some earlier time it was a *square*, and that this shape had undergone the process of elongation to make it fit the known characteristics of Egyptian geography. According to some the ceiling was flat and was supported by four huge pillars or four lofty peaks at the cardinal points, which were connected by a continuous chain of mountains. On a ledge, a little below the tops of these, the celestial river *Ur-nes* flowed round the earth, carrying the boats of the Sun and other gods; "on the northern part" the river flows through the valley of *Dait*, filled with darkness and hidden from us by mountains. This account is obviously akin to the primitive cosmological belief of the Sun's daily passage round a mountain; perhaps the reference to *Ur-nes* flowing "round the earth" may not be unrelated to the Baby-

[1] Maspero: *Dawn of Civilization.*

lonian conception of the earth rising up like a mountain at the centre of the world. Further similarity to the *Meru* Cosmology is provided by their explanation of the annual change of altitude of the Sun: during the course of the year the *Ur-nes* ebbs and flows, carrying the Sun's bark farther from, or nearer to, man, the bark always keeping to the bank nearest to man; at summer solstice the river, as also its terrestrial branch, the Nile, overflows, so that

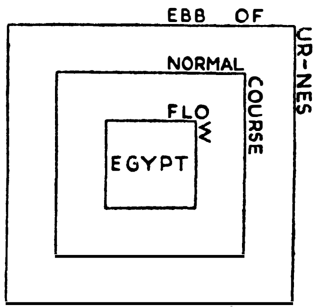


FIG. 31

the Sun's orbit is nearest to man, and his altitude highest; at winter solstice, the river is at its lowest ebb, and the Sun at the least altitude. There are also references to the *Ur-nes* turning *sharply round* at the Southern point. The whole description is illustrated in Fig. 31, which is similar to the Sun's courses in the *Sūryaprajñapti* (see Chapter IV, Fig. 14).

There is a second account which, though not so explicit as the former, seems to me to be an apt description of the Universe based on the square and its four divisions. Maspero[1] relates a cosmogonic belief of the eastern cities

[1] Maspero: *Dawn of Civilization*, p. 128.

of the Delta, according to which the goddess *Nuit* was forcibly separated from the god of the Earth and lifted up by a new god *Shu.* "Though the starry body of the goddess extended in space—her head being to the west and her loins to the east—her feet and hands hung down to the earth. These were the four pillars of the firmament under another form, and four gods of four adjacent principalities were in charge of them. *Osiris,* or *Horus* the sparrow-hawk, presided over the southern and *Sit* over the northern pillar; *Thot* over that of the west, and *Sapdi,* the author of the zodiacal light, over that of the east. They had divided the world among themselves into four regions, or rather into four 'houses,' bounded by those mountains which surround it, and by the diameters intersecting between the pillars. Each of these houses belonged to one and one only; none of the other three, not even the sun himself, might enter it, dwell there, or even pass through it, without having obtained its master's permission."

These four deities are "stellar gods," probably represented by the same stars as in China, India, Persia, etc., viz. Antares, Aldebaran, Regulus, and Fomalhaut. Thus we have, as in other countries, the four divisions of the sky connected with the four seasons and the four regions of the earth; the four pillars of the firmament with the solstices and equinoxes and the four cardinal points. At the same time, however, there is the inconsistent description of the goddess as facing west, in which case the hands and feet must occupy the middle directions S.W., N.W., N.E., and S.E. This is perhaps an instance of "change

of orientation," the side connecting the north and west corners coming to be called the "west" side. Nevertheless, the illustration given by Maspero at least shows that the sky was not imagined to be a circular vault, but rather to be of the shape of a (truncated) pyramid.

§ 2. The Pyramids

I have explained in various preceding pages how the Pyramids could be models of the Universe or of the earth. Their astronomical importance has been recognized by many scholars, to some of whose theories I have adverted. Thus Lockyer showed how these buildings were at a very early time orientated towards the rising sun at a solstice, and later to the rising of Sirius and other prominent stars at the equinoxes. In the former case, the orientation was found to change with the latitude of the place.

The astronomical significance of the pyramids may be understood from the kindred monuments of mystery, the Sphinxes, that are often found in their vicinity. The Sphinx usually "had the head and breast of a virgin and the body of a lion," which perhaps symbolized the junction of the constellations Leo and Virgo at the summer solstice in the fourth millennium B.C. The summer solstice was of mystic significance to the Egyptians, for it was marked by the highest altitude of the sun in Leo, when the celestial *Ur-nes*, accompanied by the terrestrial Nile, overflowed, and lions made their appearance in the cities.[1]

[1] For this view cf. Brennand's *Hindu Astronomy*, p. 13.

§ 3. The Divisions of the Zodiac

Besides the four divisions of space, the Egyptians seem to have divided the surrounding space into "twelve localities." The later book, *Am Duat*, mentions the twelve localities of the other world illuminated by the sun during the 12 hours of the night. Remembering that the Egyptians, like the Babylonians, originally divided the day into 12 double-hours, one might infer that they merely transferred this system later into each half of the day and each half of the world. Their 12 deities *Rā-Ammon*, etc., preceded the days when the Greeks called the zodiacal signs Aries, Taurus, etc. The Copts knew of a series of 28 Lunar Stations represented by almost the same stars as in the other ancient countries.

The Egyptians might have known the scale of 28 square divisions; an Egyptian satirical papyrus of *c.* 1200 B.C. contains an illustration of the side view of a board whose edge is divided into 8 parts, on which a game is played by the Lion and the Unicorn (see Chapter VI, § 6).

On one of the stones of a temple at Achmin "may be traced four concentric circles in a *square*, the innermost of which contains the Sun; of the next two, one contains 12 birds, the other 12 animals almost effaced, which appear to be the signs of the Zodiac. . . . *The four seasons occupy the angles of the square.*"[1] The connection between the seasons and the angles is again seen, as in other countries, by the fact that at these times they offered

[1] Brennand's *Hindu Astronomy*, p. 15 (quotation from the *Encyclopædia Metropolitana*).

sacrifices, and the sacrificial remnants were deposited at the *corners* of the temples and other buildings.[1]

THE OLD TESTAMENT

§ 4. The Shape of the Earth

The square shape of the earth seems to be meant by the references to the "four corners of the earth" in Isaiah (xi. 12) and in Ezekiel (vii. 2). Some have contested this view on the ground that there are references to "the circle of the earth"[2] and to the limiting circle on the surface of the water,[3] concluding therefrom that the corners (*kanephoth*) refer only to the "wings" or sides,[4] or merely to "the four extremities of the terrestrial disk."[5] But it is quite possible that the so-called "circle" (*ḥug*) might have denoted, like the *Chakra* in India, any enclosure in general. Schiaparelli adds the comment that "The *four edges* of the earth recall the title 'King of the four parts of the earth' (*šar kibrat irbitti*) which is used by many kings of Babylonia and Assyria and contains an analogous idea."[6] In this he has (unconsciously) supported the idea of the square shape, as it has been shown in Chapter VI that the Babylonians conceived the earth as four-sided. As in Babylonia, there was the idea of sanctity attached to the corners of the

[1] Cf. *E.R.E.*, Vol. IV, p. 120 *et seq.*

[2] Is. xl. 22.

[3] Job xxvi. 10; Prov. viii. 27, etc.

[4] Cf. E. W. Maunder in *The International Standard Biblical Encyclopædia*, Vol. I, p. 314 *et seq.*

[5] Cf. Schiaparelli: *Astronomy in the Old Testament*, p. 24, footnote.

[6] *Loc. cit.*

buildings and fields, no doubt due to the square shape of the earth.[1]

There are again several allusions to the earth as a solid structure, e.g. the several references to "the pillars of the earth,"[2] and one reference to "the vault upon the earth." Some have regarded the latter reference as a description of the heavens covering the earth like a bell,[3] while others infer that the earth was regarded as a spherical cap.[4] Perhaps the vault might also have been pyramidal. The Book of Job (xxxviii. 4–6) represents the earth as a vast building erected after careful mathematical planning and laying of foundation-stones at the corners:

> Where wast thou when I founded the earth?
> . . . . .
> Who fixed the measures thereof,
> Or, who fixed the line over it?
> And whereupon were the sockets thereof sunk,
> Or who laid the corner-stone thereof,
> . . . . . ?

There are similar descriptions of the earth as a building in the Babylonian Epic of Creation (iv):

> And the Lord measured the construction of the Deep,
> And he founded Esharra, a mansion like unto it,
> The mansion Esharra, which he built like heaven.[5]

§ 5. Ezekiel's Vision

The chapters xl–xlviii of the Book of Ezekiel relate how the Lord revealed to the prophet the Temple of

[1] *E.R.E.*, Vol. IV, p. 120.
[2] Job ix. 6; etc.
[3] Cf. Schiaparelli, *loc. cit.*
[4] Cf. Maunder, *loc. cit.*
[5] *Esharra* = Earth, according to Jensen: *Kosmologie der Babylonier*, VI, 344, and Zimmern: *Die Keilinschriften*, etc., IV. pp. 496, 510).

God and the City of God on the top of a high mountain. The Temple appears as a square of side equal to 500 reeds, with a gate at the middle of each side, one reed square. There is a pavement inside running round the boundary, 50 cubits wide, and apparently based on a system of unit squares. An "outer court" separates it from "the inner court" which is "an hundred cubits long, and an hundred cubits wide, four-square"; at its centre is the Altar 12 cubits square standing on a square settle which is 14 cubits long and is surrounded by a border half a cubit wide. The Temple is bordered by a "suburb," 50 cubits wide; the whole plan forms a series of square borders. The Holy of Holies was a square of side 20 cubits; even "the posts of the Temple were squared, and the face of the sanctuary; the appearance of the one as the appearance of the other." To the south of the Temple stood the City of God, a square of side 4,500 reeds, surrounded by a border 250 reeds wide forming the suburb.

It is well known that the Vision does not represent any actual temple; for (1) it is on the top of a mountain while the actual Zion is not; (2) the outer court alone is nearly 4½ miles in circumference, which is a mile more than the *whole* city of Jerusalem, and about 6 times the size of the actual temple, and (3) the latter stands in the midst of Jerusalem, whereas the Temple in the Vision is entirely separated from the City of God. This Temple stands at the centre of the "Holy Portion" which is a square of 25,000 reeds; the land to the north and south is partitioned among the "twelve tribes of Israel" (see

below). The whole description has been supposed to be an allegorical representation of the division of the earth, similar to that attributed to the Chinese mythical Emperor *Yao.*[1]

The Vision of Ezekiel has been compared[2] to the Tabernacle in the Wilderness (Exod. xxv), the Temple of Solomon (1 Kings vi, vii), and the Apocalyptic Church. Of the astronomical characteristics common to their design, the first is, of course, that they are all "four square"; and what is more, the Holy of Holies in the Tabernacle and in the Temple and the "heavenly city" of the Apocalypse are *perfect cubes.* Secondly, the four sides are connected in every case with a series of 12 entities akin to the divisions of the Zodiac (see below, § 6). These show that the "Temple of God" is possibly only the Heaven or the earth conceived on the system of square divisions.

§ 6. The Divisions of the Zodiac

The 12 zodiacal divisions appear connected with the square in the descriptions of the four Ideal Buildings mentioned above: "Around the Tabernacle the host of Israel, ranged in its Twelve Tribes, was encamped in a quadrilateral form, so as to guard its four sides; and on each of these four sides there were 3 tribes" (cf. Num. ii); "in the Temple of the Brasen Laver, the vessel which contained the water for ablution . . . was placed on the

[1] Cf. Chapter V, § 7, Legge's *Classics*: the *Shu-King*, Part III, Book I.

[2] Bishop Wordsworth: *The Holy Bible*, with Notes, etc., Vol. V, p. 275 *et seq.* (notes).

back of Twelve Oxen, types of God's ministers, three looking to the north, three to the west, three to the south, and three to the east . . ." (cf. 1 Kings vii. 25); in the Vision of Ezekiel, the Holy City has three gates on each of the four sides, named after the Twelve Tribes of Israel; in the Apocalypse, the Holy City has 3 gates on each side, "and at the Twelve Gates are Twelve Angels, and the names are written thereon of the Twelve Tribes of the Children of Israel" (cf. Rev. xxi. 12); all these 12 entities, as well as the 12 Apostles, have been supposed to be allegorical representations of the twelve signs. The Apostolic Church is represented as a woman having a diadem of Twelve Stars on her head, and is described as having "Twelve Foundations and in them the names of the Apostles."

The distribution of the divisions of the Zodiac at the rate of *3* to a side would suit the stage in which some or all of the 12 square divisions are replaced by *triangles* so that there are 3 divisions on each side (see Chapter III, § 7). The allegorical interpretation would thus indicate a Heaven (or Earth) based on a square associated with 12 divisions.

In the first chapter of Ezekiel is related the prophet's vision, near the river Chebar, of *four cherubims*, described as having "four faces" and "four wings" each, as moving "like a wheel within a wheel," etc. The invariable "quadriform character of the cherubs" is a matter of usual comment, though theologians interpret it as the fourfold aspect of the universality of Christ, etc. Their astronomical nature can be realized from the description that

ensues, which endows them with the faces of a man, a lion, an ox, and an eagle: now these are the constellations associated with the solstices and the equinoxes, the Lion of the summer solstice, the Bull of the vernal equinox, the Eagle, the early constellation that furnished the *Nakshatras* of the winter quarter, and perhaps the Babylonian Scorpion-man of the autumnal equinox; in the Apocalypse of St. John, the cherubs are called "living creatures"—no doubt, of the Zodiac. Similar constellations guarding the four quarters have been shown to exist in other ancient countries. Moreover, "the quadriform character of the cherubs" will now be seen to apply to the quarters of the square which are similar to one another and to the whole, each appearing like "a wheel within a wheel"—remembering that a "wheel" was not necessarily circular. Perhaps the "wings" might have referred to the "corners" (*kanephoth*); so that the cherub has four faces and four corners; and it is clear how "their wings (corners) are joined to one another." The description following is more obscure, e.g. there are allusions to the division of the wings, the joining of the divisions, etc., which are capable of referring to the method of obtaining the 12 divisions from the 4 divisions; but there cannot be the same certainty about it as about the interpretation of the cherubs.

Of other divisions of the Zodiac, the Lunar Mansions have been supposed to be intended by the Hebrew *Mazzāloth* or *Mazzāroth*, which Weber supposes to be radically the same as the Arabic *Manāzil*. Brown relates it to the Babylonian *Mazārāti* or the Signs. The word has also

been used to denote the planets, and is associated with the seasons. Perhaps it might have denoted a zodiacal division in general, or any of the several series.

In one account,[1] there seems to be evidence of a division of the square enclosure into sixty parts: the sacred association of the *corners* led to the formulation of a law which forbade the reaping of the corners of the field; but doubts arose as to *how much* exactly was to be left unreaped; and the Rabbis agreed that "a just man would leave *one-sixtieth of the field* as a corner."

PERSIA, SOGDIANA. ETC.

§ 7. IRANIAN COSMOLOGY

The cosmological beliefs of the peoples of Persia and neighbouring countries offer some parallels to the *Meru* cosmology, though indeed not in respect of the square shape; these parallels, however, are useful as showing how they were all affected by the primitive cosmological beliefs. Thus the *Zendavesta*, the *Vendīdād*, and other works divide the surface of the earth into several zones —seven *karshvaras*—of which the central zone contains Iran.[2] In the *Bundahis*, the division is somewhat different, but the central zone is surrounded by a sea, and there is a lofty mountain in a zone to the north of Iran.[3] According to Al-Biruni,[4] the Zoroastrians of Sogdiana had a tradition that the world is surrounded by the mountain *Ardrīya* (cf. *Lokālōka* of the Hindus), behind which was *khōm* (cf. *Tamas*, darkness); in the centre of

[1] *E.R.E.*, Vol. IV, p. 121.

[2] Cf. *S.B.E.*, Vol. XXIII, pp. 86, 96, 102, etc.; Vol. IV, p. 377, etc.

[3] *S.B.E.*, Vol. V, p. 32 *et seq.* [4] *India*, Chapter XXIII, p. 249.

the world is the mountain *Gir-nagar* (cf. *Meru*) between our *clima* and six other *climata*, the throne of heaven. The Qurān (lxv) says: "God it is who created the seven heavens, and of the earth the like thereof."

§ 8. The Zodiacal Divisions

Besides the Four Guardians of Heaven, the Persians had the *Twelve Akhtars*, or zodiacal constellations, who helped *Ahurmazda* in his fight with the forces of Evil; these constellations were the same as those of the Greeks. They had further the 28 Lunar Mansions like the other ancient nations; but here we meet with a very suggestive name for these mansions, viz. the "sub-divisions of the astronomer" (*khurdāk-i-hāmārīkān*, literally, the "Fragments of the Calculators").[1] In the *Bundahis*, we have a direct proof of the fact that these "sub-divisions" were obtained by *immediate* division of the 12 signs: "First he produced the celestial sphere, and the zodiacal constellations (*akhtar*) are assigned to it by him; especially those twelve whose names are *Varāk* (the Lamb), *Tōrā* (the Bull), . . . Which, from their original creation, *were divided* into the twenty-eight sub-divisions of the astronomers, of which the names are *Padewar*. . . ."[2]

The Khorasmians seem to have meant the Lunar Stations by the *Akhtars*. Thus Al-Biruni says:[3] "In the *Khwārīsmi* dialect an astronomer is called *Akhtar-wenīk*, i.e. 'looking to the lunar stations.'" He goes on to inform us that "They used to *distribute* these stations over the

[1] Cf. *S.B.E.*, Vol. V, p. 11, footnote.
[2] Bund, Chapter II, 2–3.
[3] *Vestiges of the Past.*

twelve signs of the Zodiac"; this distribution recalls the "superposition" of the two Zodiacs in Babylonian Uranography, the Chinese arrangement of the *sieou*, and the Persian derivation (above).

MEXICO

§ 9. The Cycles of the Aztecs[1]

The Aztecs grouped their years into "sheaves" or "bundles" of 52 years. To represent a particular year, "they divided the great cycle [of 52 years] into 4 smaller cycles, or indictions, of 13 years each. They then adopted two periodical series of signs, one consisting of their numerical dots, up to thirteen; the other, of four hieroglyphs of the years. These latter they repeated in regular succession, setting against each one a number of the corresponding series of dots, continued also in regular succession up to thirteen." These combinations are "generally thrown into the form of wheels, as are those also of their months and days, having a very pretty effect. . . . The wheel of the great cycle of 52 years is encompassed by a serpent, which was also the symbol of 'an age' both with the Persians and Egyptians." Here we have a cycle of 52 time-intervals represented by a wheel divided into 52 parts which are grouped into 4 main portions. Obviously such a graduation of the circle must have been too difficult for the originators of the wheel; it is more easy to obtain 52 square divisions by bordering the square; moreover, the divisions would naturally fall into 4 main groups according to the "cardinal division," and the squares round the square wheel are more suitable than linear

[1] Cf. Prescott: *History of the Conquest of Mexico*, Bk. I, Chapter IV.

divisions for containing their symbols, the dots, and the 4 signs, which could be repeated round the wheel (cf. the shells placed by the Indian astrologer in the squares).

The Scale of Twenty might have similarly played its part in giving the Aztecs their *vigesimal* system:[1] they denoted the first 19 numbers by a corresponding number of dots, and multiples of twenty by repetition of the hieroglyphic sign for 20, viz. a flag. Even here, "their mystic number, 4" appears as the first *four* numbers which had separate names, and were added after the names of 5, 10, 15, etc., to express the intermediate numbers. Their civil year was divided into 18 months of *20* days each; and the month into *4* weeks of 5 days each. The Aztec priests had an "astrological year" consisting of *20* "lunar months" of 13 days each.

All these cycles and divisions are such as could be represented by means of our scales obtained by the method of bordering.

The end of the Great Cycle—at winter solstice—was marked by a festival at which the sacred fire, usually kept unextinguished at the top of their temples, was allowed to go out, victims were sacrificed, and the fire was re-kindled to inaugurate the new cycle. The Temples, called the *Teocallis* or "houses of God," were immense pyramids with a number of stories; usually "the ascent was by a flight of steps, *at an angle of the pyramid,* on the outside."

[1] This system is, of course, explicable on physiological lines (see Chapter I, § 9). But its presence here in intimate connection with systems based on *4* and *52* would rather favour the hypothesis of "borders."

CHAPTER VIII

SOME PRACTICAL APPLICATIONS

It is found desirable to collect together in this chapter some of the practical appliances derived from the square scales, and other concrete forms assumed by the idea of the square cosmos.

§ 1. The Gnomon and the Sun-dial

In an earlier chapter (II, § 4) we have discussed the possible connection between the "complete gnomon" or "border" and the instrument called the "gnomon": how the instrument first introduced into Greece by Anaximander consisted of a horizontal surface resembling the sun-dial,[1] and a pointer which cast shadows on it: and how the different compartments of the closed "border," probably marked on the horizontal surface, would help to "read off" or "know" the shadow easily, thus suggesting the name of the instrument. It was also shown how this could have been abridged to the L-shaped gnomon and used for the measurement of shadows.[2]

The hypothesis of an early square dial is found useful in elucidating an obscure "astronomical myth" of the Hindus[3] about *Sam-jñā* (from the same root as "gno-

[1] Cf. D. E. Smith: *History of Mathematics*, Vol. I, p. 69; also Heath: *Greek Mathematics*, Vol. I, p. 78 *et seq.*

[2] This is supposed to be merely an instrument for drawing right angles.

[3] Cf. G. R. Kaye: *Hindu Astronomy*, p. 106.

mon"), and in co-ordinating other objects often associated together. In the myth the Sun is married to *Sam-jñā*, who is dazzled by the Sun, and is given *Chhāyā*, the shadow, as a handmaid for succour; then follows an escapade which ends in their begetting the two *Aświns*; there is also an allusion to the breaking of an eighth part, etc. The myth may refer to a square dial whose edge is divided into eight parts so as to give a scale of twenty-eight divisions or *Nakshatras*; consistently with the appellation of the *Nakshatras* as the offspring of the Ecliptic (see Chapter III, § 3), the regent deities of the *Nakshatra Aśvinī* (α, β Arietis) are stated to be born of the dial; the dial is also connected with shadow-measurement and is called by a name equivalent to the "gnomon." Perhaps the same square scheme embraces two other objects mentioned in the same story, viz. the *chakra* of *Vishnu* and the Trident; the latter is derivable from our cardinal figure; the *chakra* was the name of the "wheel" or astrolabe, which was later circular, and was probably a square in earlier times, like the *Rāśi-chakra* or Wheel of Signs.[1]

"The Earliest Sun-dial" extant is not circular, but consists of a linear scale with a cross-piece attached to it at right angles for throwing shadows. This comes from Egypt and is shown in Breasted's *Ancient Times* (see Fig. 32). It has some resemblance to the L-shaped gnomon, and both might have been used in the same way.

[1] See Chapter III, § 5; also cf. the "four-cornered" *vajra* of Indra (Chapter III, § 6)—the chief of the Vedic pantheon corresponding to *Vishnu* of post-Vedic mythology.

The nearest approach to the square pattern is found on a "ham-shaped" portable dial (Fig. 33) that comes from Herculaneum, and bears signs of being made between 28 B.C. and A.D. 60.[1] The pattern is divided into

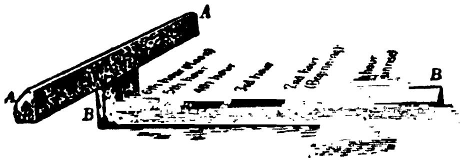


FIG. 32

six straight columns corresponding to the six months from summer solstice to winter solstice, and vice versa; there are six rows separated by curved lines so as to indicate the "hours," every "day," whether long or short,

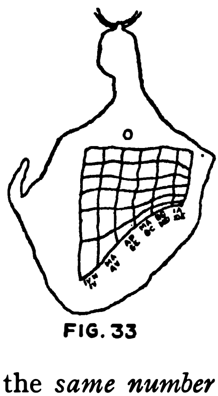


FIG. 33

being divided into the *same number of hours.* A square with graduated sides frequently served as the basis for the scales engraved on medieval dials, astrolabes, etc.

In Judea, there appears to have been some sort of a structure used for shadow measurement. It was possibly

[1] Cf. Mrs. A. Gatty: *The Book of Sun-dials,* p. 183 *et seq.*

made up of a series of steps like a pyramid with a pinnacle on the top to cast the shadows, which were reckoned by the steps. There are references to this in two obscure passages of the Bible: The Second Book of Kings (xx. 9–11) relates how, when Hezekiah, king of Judah, wished for a sign of the speedy recovery promised him by Isaiah, "Isaiah said: Let this be a sign from Yahwe that He will do the thing that he hath spoken. Shall the shadow go forward ten *ma'āloth*, or go back ten *ma'āloth*? And Hezekiah said: It is easy for the shadow to go down ten *ma'āloth* (farther), but not that the shadow return back ten *ma'āloth*. And Isaiah the prophet cried unto Yahwe, and He made the shadow return by as many *ma'āloth* as it had gone down on the *ma'āloth of Ahaz*, namely, ten *ma'āloth* back." The other passage is in Isaiah (xxxviii. 8).

Schiaparelli[1] pictures the account as follows: "Ahaz, on the occasion of the new buildings arranged by him in the Temple and the royal palace, had caused a flight of steps to be made, which was called in consequence the *ma'āloth*, or steps, of Ahaz. The shadow of some higher part of the edifice projected over these steps; this shadow, gliding from step to step, was continuing to descend at the hour of the day when the prodigy occurred. It is not impossible that these steps were used by some as points of reference for guiding themselves as to time; this is a natural proceeding, and analogous practices have been adopted at all times and places."

On the theory of the square graduations, the flight of steps was in all probability constructed on all the

[1] Cf. *Astronomy in the Old Testament*, pp. 96–9.

four sides of the square base leading up to the pinnacle on the top of this pyramidal *ma'āloth*; the sun's shadow would lie on these steps during the whole day, so that the *direction* as well as the altitude of the sun could be known. The plan of the whole building would form a series of square "borders" at distances of a unit; each "border" would also consist of a number of unit squares, representing one of the series of divisions of the Zodiac. One wonders whether there is any connection between these zodiacal divisions, the *Mazzāloth* (in Hebrew), and the *Ma'āloth*. If so, one could be certain of the intimate connection between the original zodiacal divisions and the original instruments like sun-dials, astrolabes, and quadrants. Further, if the sun-dial was a pyramidal structure, we can understand why the northern edge of the pyramid in the *Meru* Cosmology (cf. Chapter IV, § 5) was inclined so as to point to the meridian altitude of the sun at Winter Solstice. (See footnote pp. 85 f.)

§ 2. Game-Boards

Surprising though it may appear, certain games were bound up with astronomy. Thus *Chess* was astronomical in origin; in China it was called *Siang k'i*, which is usually translated as the "Astronomical Game" or the "Figure Game."[1] In several Persian and Arabic stories chess and certain games played with dice are stated to have been modelled upon the heavens, e.g. the *Chatrang-nāmak* mentions[2] a game with 30 men, "15 white in the likeness

[1] Cf. Murray: *History of Chess*, p. 121. Cf. also Chapter VI, § 6.
[2] *Ibid.*, p. 151 *et seq.*

of the day and 15 black in the likeness of the night," and "the movement of each (fashioned) after the likeness of the movement of the constellations, and in the likeness of the revolution of the firmament," apparently similar to the way in which "the 7 stars move in 12 fixed circles," etc. One of the several Muslim legends that assign their origin to India says that an Indian philosopher, Qaflān, invented the game of nard to symbolize man's relation to his environment and to fate: the board, which stood for the year, had 12 points or houses on each half to symbolize 12 months of the year or the 12 signs of the Zodiac,[1] etc. These accounts illustrate the explanation here attempted of the ancient custom of representing the year-cycle and its subintervals by the square division with the aid of concrete objects. The board might, moreover, have originally been a kind of planisphere, on which the motion of the "seven planets" was also represented by moving corresponding "dogs" to appropriate squares; later the representation might have lost its meaning and become a mere "game"; our Knight's move, for instance, might have originated from the motion of the bodies "round a corner" in their celestial orbits or on the original chequer-board.

The board of 8 × 8 squares was known in very early times: in Vedic India there are references to the game of *ashṭāpada* (= "Eight-Divisions"), the name clearly describing the eight divisions on each side of the square diagram; the Egyptian illustration of the side view of

[1] Cf. Murray: *History of Chess*, p. 209 *et seq.*

a board with 8 divisions on the edge and with a Lion and a Unicorn on either side playing a game of chess has already been referred to (Chapter VI, § 6; also Chapter VII, § 3).

The early connection of these boards with the zodiacal divisions is seen from the use of the word "house" for the squares on the board, as well as for the Signs and the Lunar *Mansions.* The board was called in ancient India by the names *Koshṭhikā* or *Koshṭhāgāra,* a "storehouse" or "granary"; the word also means a "house," thus presenting "a complete parallel to the Arabic *bait,* house, and the Italian *casa* (French *case*), house, which are both used in the technical sense of square of the board."[1] One might also mention the symbols of the Signs and other astronomical symbols found on the early boards, like the one from Ur (Chapter VI, § 6); one figure divided into 8 × 8 squares, found in Tibet and supposed to be a "divinatory diagram," or else a "Buddhist promotion-game,"[2] exhibits a number of such symbols which might have an astronomical significance, e.g. the Lion, the Eagle, the Horse, the Elephant,[3] the Snake, the Tree of Life, the magic square, the cross, the swastika,[4] the eight-rayed star, etc. The representation of these pictures on the squares, moreover, is in harmony with the "picture-theory" of the origin of the zodiacal constellations.[5]

[1] Cf. Murray: *History of Chess,* p. 51. [2] *Ibid.,* p. 43.

[3] Cf. Vedic list of sacrificial animals, Chapter III; also Appendix I, col. 6.

[4] See below, § 4. [5] Cf. Chapters II, III.

§ 3. Architecture

The same plan of the Universe that furnished the game-boards was also responsible for providing the architects with plans of their cities and buildings. In the *Rāmāyaṇa* (I. v. 22), Ayodhyā (ancient Oudh) is spoken of as "charming by reason of pictures consisting of *ashṭāpada* squares, as it were painted." Murray's comment on this description is instructive: "The regular plan of the city is probably intended, and the passage may be compared with later ones from Muslim historians. Thus Hamza al-Isfahāni (*c.* 300/912), writing of the building of Jundū-Shāpūr by the Sasanian king Shāhpūr (A.D. 240–270) says: 'the plan of this city was after the fashion of a chess-board: it was intersected by 8 times 8 streets,' to which a later Persian historian adds the pertinent comment, 'the figure was after this fashion but chess had not yet been invented at that time.' The later geographer Mustawfī (740/1340) has a similar statement about the plan of Nīshāpūr in Khurāsān: 'In the days of the Chosroes, as it was reported, the old town of Naysābūr had been originally laid out on the plan of a chess-board with 8 squares to each side.' There is also a passage in a northern Buddhist work, cited by Burnouf in his *Lotus de la bonne loi*, Paris, 1852–54, p. 383, in which the world is described as 'the earth on which *ashṭāpadas* were fastened with cords of gold.' "[1]

Other architectural evidence has been given already in Chapter III, §§ 7, 8, Chapter VI, § 8, and Chapter VII, §§ 2, 3, 5, and 6 above.

[1] *Op. cit.*, p. 33.

It was but natural that the ancients should have attempted to house the images of the Heavenly Beings in buildings that were models of the Heavens. The scheme was applied to other buildings, like palaces and observatories: e.g. the building at Khorsabad, supposed to be an observatory (see Frontispiece), is seen to be an imitation of the Babylonian Temple; and "the most striking features" of Darius' palace, as Fergusson remarks,[1] are the immense staircases leading from the plain to the platform—these are based on the same square form, and further recall the description of the *ma'ăloth* of Ahaz (§ 1). Similarly, the Tomb of Cyrus at Passargadae was a small "stone copy" of the Babylonian Temples;[2] and the Tomb of Darius at Naksh-i-Rustam is cut in the rock as "an exact reproduction of the architectural features of the palace, and to the same scale," to serve him as an "eternal dwelling" after death.[3] The Tomb of Cyrus is surrounded by an "open screen of pillars" which appear to have been 28 in number; and curiously enough, the frontage of the tomb of Darius shows 28 men carrying a platform on which stands a priest extending a prayer of welcome(?) to a winged god in front of a disk, etc.

I do not propose to go into the details of early Hindu architecture. Suffice it to say that it is based on the same scheme, often called "Indo-Persian architecture."

It is important to realize the connection in primitive times between architecture and cosmology. What more abiding plan, shape, or size could the architect think of

[1] *History of Architecture*, Vol. I, p. 190.
[2] *Ibid.*, Book II, Chapter II.
[3] *Ibid.*, p. 195.

than the plan and shape of the Universe and the "divine proportions" exhibited in the work of the Creator? Many of the medieval sacred institutions were expressly based on these "divine proportions."

It seems a legitimate deduction that the square structures and especially the Pyramids are standing monuments testifying to the existence of the ancient square cosmology. Domes and arches appear later, and may have displaced the pyramids and the gables in the same way that the Sphere came to be regarded as the perfect form chosen by the Great Architect for the shape of the Universe.

§ 4. Art and Magic

Among the several emblems found in ancient art, the Cross in its various forms plays a prominent part. Though it is often merely decorative, it has frequently a symbolic significance:[1] Everywhere, it may be said to have been used, above all, to represent *radiation* or *space*. Thus the equilateral cross is found in Babylonia, side by side with the winged solar disk or the eight-rayed star, and was the symbol of the god *Anu* and of the sky. It is also met with in India and elsewhere. The Chinese seem to have a tradition that "God fashioned the earth in the shape of a cross."[2] The other forms of the cross are derivable from the equilateral cross. Some of these Crosses appear in very early ages, surrounded by *borders*.

[1] Cf. D'Alviella: *The Migration of Symbols*; also *E.R.E.*, Vol. IV, pp. 324–9; Budge: *Amulets and Superstitions*, etc.

[2] According to Samuel Beal (*Ind. Ant.*, 1880, p. 67)—quoted by D'Alviella.

The *Swastika* is the *Gammate* Cross or Gammadion, arranged like a clockwise couple; the counter-clockwise arrangement is called the *Sauvastika*. This is one of the sacred symbols of the Hindus, and is found to be freely employed in Buddhist works of art, e.g. on their topes, and on the *Buddha-pâda* (footprints of Buddha). It is found on terra-cotta articles at Hissarlik, in Hittite monuments, upon a vase now at Vienna as an ornament on the breast of Apollo, and upon Gallic and Teutonic jewels and weapons, and those of the Bronze Age; in China it connoted "abundance" or "prosperity," the Aztecs and the Egyptians considered it sacred, and the Maoris, "the race of pyramid-builders," treasured it as a *Life-Symbol.*[1] The reason for the veneration rendered to this symbol may be due to its derivation from the cardinal division of the square which was the base on which their pyramidal universe was erected, together with the indication of the motion of revolution which it conveys.

Some of the above symbols, like the square and its divisions, were employed in magic. The use, by the magicians in India, of the several *Chakras* like the pentagram, the 8-rayed star, the 16-rayed and the 64-rayed stars, has already been referred to (see Chapter III, § 5). These stars are usually inscribed in the square, and the process of drawing the square or "cutting the *Chakra*" was itself an occult act attended with magical rites. Many of these figures inscribed in squares, or having square patterns, are found on ancient amulets[2] used to

[1] Cf. E. Rout: *Maori Symbolism.*

[2] Cf. Sir Wallis Budge: *Amulets and Superstitions.*

bring good luck or to ward off evil spirits. One type of these amulets[1] deserves special mention; the Solar disk is drawn with a *square face*, and eight horns pointing to the eight directions.

The amulets and the magical diagrams are almost always connected with the Signs or other divisions of the Zodiac (and related astronomical notions). The Zodiac was itself called "the Lady's Wheel" or "Fortune's Wheel"; and the Signs, etc., were used by the astrologer for purposes of divination and prediction; also the different divisions of the Zodiac were associated with various deities ruling in those quarters of the Universe, and the divisions were related to the *Chakras*. The association of astronomical notions through astrology with magic is not doubtful, and would have naturally led to the utilization of the square form of the Universe and its parts for magical purposes.

[1] Cf. Sir Wallis Budge: *Amulets and Superstitions*, pp. 188, 190, 193, 194.

CHAPTER IX

EARLY COSMOLOGY: A *RÉSUMÉ*

THE foregoing chapters have set forth the evidence in support of the theory put forward (see Chapter II, § 8) regarding the early conceptions of the Universe. We may now take a bird's-eye view of our reconstruction of the World as the ancients saw it.

§ 1. THE DIVISIONS OF THE ENCLOSURE

The early mathematician had succeeded in dividing the enclosure—easily drawn in the form of a square—into a series of divisions.[1] In China the 4 "Imperial Palaces," the 12 "Council-Chambers," and the 28 "Mansions" were arranged as though they had been derived from such division of the square;[2] in Persia, the 12 divisions are stated to have been further divided *immediately* into the 28 "subdivisions of the astronomer" or "fragments of the calculator";[3] the Hebrew priests declared that a "corner" of the field was $\frac{1}{60}$, probably because of the 60 squares into which the edge of the field could be divided;[4] in India, besides these divisions, there were divisions into 124 parts and (probably) 252 parts.[5] The mathematician had also obtained a wider series by the method of "bordering" the square scale

[1] Chapter II, § 1.
[2] Chapter V, § 4; also §§ 3, 5.
[3] Chapter VII, § 8.
[4] Chapter VII, § 6.
[5] Chapter II, § 1; Chapter III, § 4.

with series of unit squares.[1] Counting each square division as a unit he could use each scale to represent a number; the numbers of the series, 4, 12, 28, 60,—or of the series 4, 12, 20, 28, 36,—were regarded as basic, and capable of being used as bases of numerical systems, like the set of 4 symbols of the Aztecs,[2] or the duodecimal, the vigesimal, or the sexagesimal system. As a particular case, the unit square could be employed to denote a time-interval like the month or sign; and the whole enclosure with a certain number of unit squares would represent a *cycle* consisting of a corresponding number of sub-intervals, like the day of 12 double hours, or the Mexican Great Cycle of 52 years.[3] The square division or "house" was also adapted for the representation of any event by placing a concrete object *in* the square: e.g. the position of the sun or moon or any celestial body could be represented at any time by placing a number of shells (like the practice of the astrologer in India) or a pictorial symbol of the body in the appropriate square.

The mathematician was also an astronomer; he noticed how the celestial bodies completed their motion round the heavens in periods that happened to correspond roughly to the numbers he had obtained by his natural process of dividing. Thus the cardinal division of the square was reflected, as it were, by the *four* seasons, into which the year was naturally divided by the equinoxes (when days and nights were equal and the Sun rose

[1] Chapter II, § 2.
[2] Chapter VII, § 9.
[3] Chapter VII, § 9.

exactly in the east) and the solstices (when the "day" was longest or shortest, and the point of Sun-rise began to "return"); and the moon's period of waxing and waning, the month, was divided into *four* by the full moon, the new moon, and the quarters. There were 12 of these periods of the moon in the period of the Sun (the year); and 12 years in the period of Jupiter, "the King." The 28 "sub-divisions of the astronomer" were chosen by the moon as "alighting stations" or "inns" where she could rest for a day during her journey among the stars (in a period of about 28 days). The cycle of 60 years was known to all the nations; the Hindus noted it as marking the recurrence of a conjunction of the sun, moon, and Jupiter in the same *Nakshatra*; some of the Vedic texts describe the month as consisting of "60 days and nights." The observation of these phenomena that recurred in harmony with the basic numbers must have confirmed them in the belief in the mystic significance of those numbers. Hence the sacredness of some of the numbers to the Hindu; the Babylonian scale of numbers attached to their deities;[1] and the Pythagorean doctrine that "numbers rule the Universe." Plato was the last of the early philosophers who held that the Universe was constituted by Number and Form. The *Platonic Number* (60^4) was the highest number in some of the Babylonian mathematical tablets. The Hindus had similar large cosmic numbers (Chapter III, § 4), of which the largest I have seen is 18,446,744,073,709,551,615—connected with the First

[1] Chapter VI, § 3.

Cause of the Universe, and stated to have been arrived at by a method of "doubling the squares of the chess-board";[1] the number is easily seen to be $2^{64}-1$ or the sum of a geometric progression of 64 terms beginning with 1 and multiplying by the common ratio 2; the method referred to is perhaps the same as the process of our repeated division of the square.

§ 2. THE FORM OF THE WORLD

(*a*) *The Universe* was founded on a square base—with "four directions" or "four sides" and "four quarters." On this plan the World was erected "on high" by the sage, the "celestial Architect" (*Tvastṛi*) of the *Ṛig-Veda*, the Lord (in the Bible) who fixed the measures, sunk the sockets, and laid the corner-stones thereof, the Lord who erected the Babylonian *Esharra*. The structure was either a prism like the Egyptian rectangular box,[2] or the Chinese cubical World, or the cubical "Holy of Holies" in the Temple of Solomon and other Biblical descriptions;[3] or else a pyramid, as in the case of the hollow Mountain of Nippur;[4] or a combination of both, i.e. a cuboid with vertical walls crowned by a pyramid, the shape seen figured on several Babylonian boundary-stones.[5] Vertical walls bounding the Universe are found in the *Lokālōkas*[6] of the Hindus (behind which is *Tamas*, darkness), the *Ardrīya* of the Zoroastrians[7] (behind which is *Khōm*),

[1] Cf. Murray, p. 210.
[2] Chapter VII, § 1.
[3] Chapter VII, § 5.
[4] Chapter I, § 4; also Chapter VI, § 8.
[5] Chapter VI, § 5.
[6] Chapter I, § 5.
[7] Chapter VII, § 7.

and the Egyptian chain of mountains[1] connecting the pillars at the four cardinal points.

(*b*) *The Heavens* would thus be a flat ceiling, or a pyramid supported by pillars at the corners (cf. Egypt, *Ṛig-Veda,* and Old Testament). The celestial bodies moved in rectilinear orbits, turning sharply at the corners; they described different daily orbits lying on horizontal planes (the same for one body) at definite heights above the base, the orbits getting wider during one-half of their periods and narrower during the other half; by this means their periodic change of altitude (the obliquity of the ecliptic in the case of the sun) was accounted for. Such accounts of the orbits appear in the Hindu *Purāṇas,* the *Sūryaprajñapti,* the *Tcheou-pei* of the Chinese and in Egyptian cosmology. Some of the celestial bodies even were square-shaped, e.g. the sun is stated in a Vedic text to be "four-cornered";[2] and the emblems of the sun are square-faced in amulets,[3] etc.; so were the *Chariots* of the Sun-god and other such celestial Beings.

(*c*) *The Centre of motion* was usually a huge mountain in the north, like *Meru* lying to the north of India; the Babylonians[4] and the Ionian philosopher Anaximenes mentioned the "northern or highest part" of the earth round which the sun, moon, and stars passed upon setting —this was possibly a reference to an earlier conception of the earth itself (see below) as the centre of motion— which hid the celestial bodies from human view, when they were supposed to "set." The central mountain was

[1] Chapter VII, § 1.
[2] Chapter III, § 6.
[3] Chapter VIII, § 4.
[4] Chapter I, § 4.

pyramidal as is shown by some of the descriptions in the *Purāṇas*.[1] The mountain was at the centre of the earth, in the centre of the World, and gods lived on its top—as in the case of Mount *Meru*, the *Girnagar* of the Zoroastrians, and the Greek Olympos,[2] similar axes[3] are no doubt offered by the "World-Tree" of the Chinese, the Babylonians, the Egyptians, and the Māyas, the "World-Pillar" of the *Ṛig-Veda*, the Iranian *Khanbe*, the Phoenician winged oak, the Norse *Yggdrasil*, the ancient Saxon *Irmensil*, the sacred pole of the Omahas, etc.

(*d*) *The Earth* was also square-based; that was the Chinese conception;[4] it is said to be "four-pointed" in the *Ṛig-Veda*;[5] the ancient and primitive descriptions of "the four corners of the earth"[6] have persisted in the modern phrase. As a solid structure it was regarded as a pyramid (e.g. the Babylonian "Earth-mountain"), whose interior was also hollow and of similar shape, the inter-space being the abode of the Dead.[7] The calculations in Indian astronomy (Chapter IV) show that some of the values given are satisfied by the pyramidal form of the earth. In the case of the Babylonian pyramids and the Indian "Earth," the corners pointed to the cardinal points. In some cases the Earth was also regarded as a cube, e.g. in China.

[1] Cf. Chapter IV, § 6.
[2] Chapter I, §§ 2, 5; Chapter IV; Chapter VII, § 7.
[3] Chapter V, § 7, footnote.
[4] Chapter V, § 2.
[5] Chapter III, § 6.
[6] Chapter V, §§ 4, 7; Chapter VI, § 8; Chapter VII, § 4.
[7] Chapter VI, § 8.

(*e*) *The Divisions of Space.*—The Earth and the surrounding Space were divided into various directions and various regions, in accordance with the primitive scales of the mathematician. Thus there was first the division of the horizon into four directions, east, south, west, and north, portioning the earth and the Universe into four quarters. This was followed by the division into the "12 localities of space." The next division into 28 parts is perhaps responsible for the description of the world as "the earth on which the *ashṭāpada* (8 × 8 divisions) was fastened with cords of gold."[1] The re-duplication of the quadri-partition must have given the 8 and the 16 directions. The division of space (or the horizontal plane) into a number of zones or borders corresponding to the series 4, 12, 20, 28, 36, . . . was seen in the case of China;[2] certain Biblical descriptions would also appear to imply a similar division.[3] There were probably at first only 5 zones thus ending with the 36 *decimae,* but, later they must have been increased to 7 zones—some of the Vedic *Sūtras* and the *Qurān* mention such a division,[4] while the Babylonians and other nations of Western Asia divided the earth into 7 zones[5] (though some of these might be circular); in the *Purāṇas* and in the *Sūryaprajñapti* this was elaborated into a division of the surface into 7 land zones intermixed with 7 liquid zones.[6]

(*f*) *The Constellations.*—Along with the scales, the picture-signs used by the computer for representing the

[1] Chapter VIII, § 3.
[2] Chapter V, § 7.
[3] Chapter VII, § 5.
[4] Chapter VII, § 7.
[5] Chapter I, § 4.
[6] Chapter I, § 5.

positions of bodies in his square "houses" might have been transferred to the skies, and utilized to group together the stars lying inside a particular division, in the form of a picture of an animal that could be readily recognized.[1] The chief "circle" of the heavens, the Ecliptic, or the "Furrow of Heaven" ploughed by the seven Bulls or planets, including the sun and moon, in observable periods, was especially marked out as the "circle of little creatures"; conversely these zodiacal constellations could be employed as symbols of the intervals of time, and of the corresponding divisions of space. Thus the Chinese had the 4 monster constellations connected with the four seasons and the 4 directions;[2] the Hindus, the Babylonians, and the Persians had the "Four Guardians of Heaven," Aldebaran, Regulus, Antares, and Fomalhaut.[3] Many ancient nations had the 12 constellations and the 12 months denoted by the same names.[4] They had again 28 star-groups as concrete symbols of the 28 divisions of the ecliptic;[5] the *Nakshatras* are stated to have been appointed to serve for measuring time; in many cases they are correlated with the 4 directions. There were, again, the 36 Babylonian Ecliptic constellations, representing the 36 divisions of the ecliptic (the 36 forms of *Êa*), the Decans of the Egyptians and Greeks, the *dreshkanas* of Indian astrology;

[1] For the picture-theory, see Chapter II, § 3; Chapter III, § 2; Chapter V, § 5; Chapter VI, § 6; Chapter VIII, § 2.

[2] Chapter V, § 3.

[3] *Ibid.*; see also Chapter VII, § 6: "the Cherubs."

[4] Chapter III, § 2; Chapter V, § 1; Chapter VI, § 1; Chapter VII, §§ 3, 6, 8, etc.

[5] Chapter I, § 8; Chapters III, V, VII.

three of these were alloted to each month.[1] The constellation of the vernal equinox—or of the autumnal equinox or the solstices—began the year by rising with the sun (or culminating or setting at sun-rise) and was termed the "Prince" or "Leader of the Host" or *Prajāpati* (= Lord of the Creatures);[2] the "end" of the year or other cycle was celebrated by a sacrifice at the end of which the remnants were deposited at a *corner*, and prayers offered to deities related to these constellations;[3] the custom was no doubt due to the position of the solstices and the equinoxes at the corners of the square Zodiac.

§ 3. Practical Consequences[4]

For these sacrifices they erected *Fire-Altars*, which were "the same as the Universe"; these altars were often placed on top of the Temple-towers (the *E-kur* of the Babylonians), which were models of the Universe. Besides such architectural structures, the square-cosmic idea found its expression also in symbolic art, and had enough of magical associations to be utilized by the occultist magician for charms. The square plan of the Universe and the celestial motion represented on chequer-boards came to be used as game-boards. The square scales were employed, not only for the representation of the position of bodies, as planispheres, but also as astrolabes and quadrants; the early sun-dials were also

[1] Chapter VI, § 2; also Chapter III, § [illegible]

[2] Chapter I, 4; Chapter III, 1; Chapter VI, 1; etc.

[3] Chapter III, 1; Chapter VI, 4, [illegible]; Chapter VII, 3, 4, 6.

[4] See Chapter VIII.

of the same shape; the dials for shadow-measurement were even solid structures like pyramid-stairs. Later, these instruments changed into the circular shape, like Ptolemy's astrolabe, or the Scaphe, or the masonry structure of Jai Singh's observatory.

§ 4. Analogous Transitions

It may be worth while to reflect upon the analogous processes of development which the various related concepts have undergone. The different stages may be briefly indicated as follows:

(*a*) *The Earth.*—Flat square—elongated into a rectangle—a sort of pyramid—spherical cap—sphere—spheroid (modern).

(*b*) *The World.*—Cube—rectangular block—pyramid added as a crown. Dwindles into pyramid alone—vault of Heaven.

In China, the earth is square, and the heavens round (*Tcheou-pei*).

Pyramidal Heaven, with a similar "under-world" gives the Universe the shape of an Octahedron. This develops into a Sphere → Egg-shell (of the Hindus).

(*c*) *Meru.*—Pyramid with square section—Section is rectangular at times.

Size diminishes—Shape changes into octagon, 64-sided polygon, etc., and finally becomes circular (an intermediate stage is seen in the attribution of a square base and a round top).

Finally it dwindles into a mere point on the surface of a spherical earth.

(*d*) *Ecliptic*, or *Horizon*, or other Enclosure—Square → Pentagon → Hexagon → Octagon →. . . → Circle.

(*e*) *Instruments*.—Planisphere, astrolabe, and quadrant from square forms to circular.

Sun-dial, as a pyramidal structure → Scaphe.

(*f*) *Architectural Concepts*.—Square plan of early Temples (also of Porticoes, ceilings, etc.) becomes rectangular, hexagonal, octagonal, etc. Early gables give place to later arches. Pyramidal roofs are earlier than the *domes*.

(*g*) *Symbol of the Earth*.—Chinese 田 → modern ⊕

Swastika 卐 → curved 

and eventually the Skirl  (both are symbols of "circular motion").

§ 5. Conclusion

Thus we have at the beginning of civilization a complete synthesis of the celestial phenomena into a Universe. In the ideal system, it consisted of a series of homocentric pyramids with corners pointing to the cardinal points and connected with the solstices and the equinoxes; on the top of the pyramidal earth was a pyramidal mountain perhaps reaching up to the celestial pyramid, and serving as a central world-pillar; round this, the sun, moon, and other planets moved in square orbits lying on horizontal planes at definite distances above the base. The system

varied slightly, e.g. as to the orientation of the pyramids (which faced the directions) or as to their replacement by cubes, or cubes crowned with pyramids. But in the main, the square shape continued to live as the Form of the Cosmos, finding concrete expression in architecture and art, and influencing social and religious institutions and practices of the early age. Even when the square gradually gave way to the circle, parts of the older conceptions must have persisted, as in the Pythagorean doctrines of geometric numbers, of numbers forming the matter of the Universe, and of the mystic import of the Pentagram. The transition generated doubts in the minds of the Vedic priests as to whether the fire-altars, that had to be built in the form of the Universe, should be square or polygonal or circular; and they devised methods of converting the square into the circle and vice versa. One may surmise that the system finally collapsed in the face of a new and equally rigid and complete Cosmology, such as Aristotle's system of concentric spheres based on the "endless" circle as *the* perfect figure, and on the sphere, the corresponding solid of perfect shape—worthy material for the Architect to employ as constituents of the form of the Universe.

APPENDICES

APPENDIX I

THE *TWELVE* DIVISIONS OF THE ZODIAC

1 *Akkadian Month.*	*(Meaning).*	2 *Semitic Month.*	3 *Latin Signs.*
1. Bara-ziggar	The Upright Altar	1. Niṣannu	1. Aries
2. Gut-sidi	The Directing Bull	2. Airu (Iyyar)	2. Taurus
3. Mun-ga	The Making of Bricks	3. Sivānu	3. Gemini
4. Su-kul-na	The Seizer of Seed	4. Dūzu	4. Cancer
5. Ne-ne-gar	Fire-making-fire	5. Abu	5. Leo
6. Ki-gingir-na	The Errand of Istar	6. Ululu (Elul)	6. Virgo
7. Tul-ku	The Holy Altar	7. Tisritu (Tisri)	7. Libra
8. Apin-dua	Opposite-the-Foundation	8. Arachsamna (Marcheswan)	8. Scorpio
9. Gan-ganna	The Very-cloudy	9. Kislimu (Kislev)	9. Sagittarius
10. Abba-e	The Cave of the Rising	10. Dhabītu	10. Capricornus
11. As-a-an	The Curse of Rain	11. Sabādhu (Sebat)	11. Aquarius
12. Se-kisil	The Sowing of Seed	12. Addaru	12. Pisces

NOTE—The Akkadian and Greek *Signs*, and the Persian signs and months, to the Latin signs in column 3.

APPENDIX I—*continued*

THE *TWELVE* DIVISIONS OF THE ZODIAC

4 *Hindu "Lunar Months."*	5 *Vedic "Seasonal Months."*	6 *Vedic Sacrificial Animals.*	7 *Chinese Signs.*
6. Chaitra	6. Madhu	Deer	11. Dog
7. Vaiśākha	7. Mādhava	Sparrow	10. Cock
8. Jyaiṣṭha	8. Śukra	Monkey	9. Ape
9. Āṣādha	9. Śuchi	White-footed beast: she-goat	8. Sheep
10. Śrāvaṇa	10. Nabhas	Elephant	7. Horse
11. Bhādrapada	11. Nabhasya	Snake	6. Serpent
12. Āśvina	12. Isha	Crocodile	5. Dragon
1. Kārttika	1. Ūrja	Shrieking bird; or Red animal sacred to the Moon	4. Hare
2. Mārgaśīrṣa	2. Sahas	Tiger	3. Tiger
3. Pauṣa	3. Sahasya	Bull	2. Ox
4. Māgha	4. Tapas	Rat	1. *Rat*
5. Phālguna	5. Tapasya	Pig	12. Boar

the Hindu "solar months" and signs, are all denoted by names equivalent

APPENDIX II

THE *TWENTY-EIGHT* DIVISIONS OF THE ZODIAC

[NOTE.—* indicates the divisions represented by different constellations from those in column I.]

Hindu Nakshatras. I.	*Constellations.*	*Chinese Sieou.* II.	*Arabic Manāzil.* III.
1. Kṛittikā	Pleiades	1. Mao	3. Thuraiya
2. Rohiṇī	α, θ, γ, δ, ε Tauri	2. Py	4. Dabarān
3. Mṛigaśiras	λ, ϕ^1, ϕ^2 Orionis	3. Tse	5. Haḳ'ah
4. Ārdra	α Orionis	4.*Tsan	6.*Han'ah
5. Punarvasu	α, β Gemin	5. Tsing	7. Dhirā
6. Puṣya	γ, δ, θ Cancri	6. Koui	8. Nathra
7. Āśleṣa	δ, ε, η, ρ, σ, ζ Hydrae	7. Lieou	9.*Ṭaraf
8. Magha	α, η, γ, ζ, μ, ε, Leonis	8.*Sing	10. Jabhah
9. Pūrva-Phalguni	δ, θ Leonis	9.*Chang	11. Zubrah
10. Uttara-Phalguni	β, 93 Leonis	10.*Yih	12. Ṣarfah
11. Hasta	β, δ, γ, ε, α Corvi	11. Tchin	13.*Auwā'
12. Chitra	α Virginis	12. Kio	14. Simāk

13. Svāti	ι, κ, λ Virginis or [α Boötis]	13. Kang	15. Ghafr
14. Viśākha	α, β Librae	14. Ti	16. Zubānān
15. Anurādha	β, δ, π Scorpii	15. Fang	17. Iklil
16. Jyeṣṭha	α, σ, τ Scorpii	16. Sin	18. Kalb
17. Mūla	υ, λ, κ, ι, θ, η, ζ, μ, ε Scorpii	17. Wi	19. Shaulah
18. Pūrva-Aṣāḍha	δ, ε, Sagittarii	18. Ki	20. Na'aīm
19. Uttara-Aṣāḍha	σ, ζ, Sagittarii	19. Teou	21.*Baldah
20. Abhijit	ε, ζ, α Lyrae	20.*Niou	22.*Sa'd adh-Dhābih
21. Śravaṇa	γ, α, β Aquilae	21.*Nū	23.*Sa'd Bula'
22. Śraviṣṭha	α, β, γ, δ Dephini	22.*Hiu	24.*Sa'd as-Su'ūd
23. Śatabhiṣaj	λ Aquarii, etc.	23. Goei	25. Sa'd al Akhbiyah
24. Pūrva-Bhādrapada	α, β Pegasi	24. Chi	26. Fargh al-Mukdim
25. Uttara-Bhādrapada	γ Pegasi, α Andromedae	25. Pi	27. Fargh al-Mukhir
26. Revati	ζ Piscium, etc.	26. Koi	28. Baṭn al-Hut
27. Aśvini	β, γ, (α) Arietis	27. Low	1. Sharaṭān
28. Bharaṇi	35, 39, 41 Arietis	28. Wei	2. Buṭain

APPENDIX III

THE 36 BABYLONIAN ECLIPTIC CONSTELLATIONS

1. Rikṣu Nunnu	η Piscium	The Cord of the Fishes
2. Mahrū ša rīšu Kusariqqu	β Arietis	The Westerly-one of the head of the Ram
3. Arkū ša rīšu Kusariqqu	α Arietis	The Easterly-one of the head of the Ram
4. Temennu	η Tauri	The Foundation
5. Pidnu	α Tauri	The Yoke or Furrow
6. Šur Narkabti ša iltānu	β Tauri	The Northern light of the Chariot
7. Šur Narkabti ša sūtu	ζ Tauri	The Southern light of the Chariot
8. Mahrū ša pu-u māšu	η Gemin.	The Westerly-one and the Easterly-one at the beginning of the Twins
9. Arkū ša šepīt māšu	μ Gemin.	
10. Māšu ša ri'ū	γ Gemin.	The Twin of the Shepherd
11. Maš-mašu mahrū	α Gemin.	The Westerly Twin (Castor)
12. Maš-mašu arkū	β Gemin.	The Easterly Twin (Pollux)
13. Mahrū ša pulukku ša šūtu	θ Cancri	The Westerly-one at the south of the Crab
14. Libbi Pulukku (Krippa)	ε Cancri	The middle of the Crab
15. Mahrū ša pulukku ša iltānu	γ Cancri	The Westerly-one at the north of the Crab
16. Arkū ša pulukku ša šutu	δ Cancri	The Easterly-one at the south of the Crab
17. Rīšu Arū	ε Leonis	The head of the Lion

18. Šarru	α Leonis	The King (Regulus)
19. Māru ša ribū arkat Šarru	ρ Leonis	The Small-one of the region after the King
20. Zibbat Kalab (?) Arū	θ Leonis	The End of the tail of the Dog of the Lion
21. Zibbat Arū	β Leonis	The End of the tail of the Lion
22. Šēpu arkū ša Arū	β Virginis	The Easterly-foot of the Lion
23. Šur mahrū šerū	γ Virginis	The Bright-one westerly of the Ear-of-Corn
24. Nibittu ša šerū	α Virginis	The One called the Ear-of-Corn
25. Zibānītu ša šutu	α Librae	The Southern Claw
26. Zibānītu ša iltānu	β Librae	The Northern Claw
27. Qablu ša rīšu aqrabi	δ Scorp.	The Middle-one of the head of the Scorpion
28. Qābu ša rīšu aqrabi	β Scorp.	The Front-one of the head of the Scorpion
29. Hurru	α Scorp.	(?) [Antares]
30. Māt ša ka-tar-pa	θ Ophiuchi	The star of the region in front of Pa
31.	δ Sagittarii	The star of the left hand of Sagittarius
32.	σ Sagittarii	The star of Nun-pē (the Lord-city or Eridu)
33. Qarnu Enzu	α, β Capri.	The horn of the Goat
34. Mahrū ša suhūru Enzu	γ Capri.	The Westerly-one of the tail of the Goat
35. Arkū ša suhūru Enzu	δ Capri.	The Easterly-one of the tail of the Goat.
36.	δ Aquarii	The Star of the Foundation

NOTE.—31, 32, 36 are the three "missing" stars supplied by Brown in *Primitive Constellations*.

GLOSSARY

[Ar. = Arabic; Bab. = Babylonian (whether Akkadian or Assyrian); Ch. = Chinese; Heb. = Hebrew; P. = Persian; S. = Sanskrit.]

Aditi (S.) (= boundless). The name of a Vedic goddess, daughter of *Dakṣa,* wife of *Kaśyapa,* and mother of the *Ādityas*; the earth; (dual—*aditī*) Heaven and Earth. Possibly a personification of the boundless "enclosure."

Āditya (S.). The offspring of the goddess *Aditi*; a name applied in the *Vedas* to any of the twelve solar deities representing the twelve months of the year. [The *Ṛig-Veda* makes them seven.]

Agni (S.). Fire; the Sacrificial Fire; the Fire-Altar; a Vedic deity.

Akhtar (P.). The zodiacal constellation; in Persian Mythology there were twelve of these that led the army of Ormuzd in his fight against the forces of evil.

Amśa (S.). Lit. a part or portion; a division of the ecliptic, viz. $\frac{1}{124}$ of a *Nakshatra*; a degree of latitude; name of an *Āditya* or solar deity.

Apsu (Bab.). "The Waters"; the "Great Deep" that surrounds the world; the primeval Chaos from which the world was created.

Ara (Bab.). Altar or Light. The Altar was the seventh sign of the Euphrateans; the Light or Lamp is shown on boundary stones as held in the Claws of the Scorpion.

Aṣṭāpada (S.). "Having eight divisions." A chequered board consisting of 8 × 8 squares, used for playing dice, chess, etc.

Bhārata (S.). The Sanskrit name of India.

Brahman (S.). The one self-existent impersonal spirit; the one Universal Soul; the Cosmos; the manifestation of the Universal Spirit as a Personal Creator; also referred to as *Prajāpati*.

Brahmāṇḍa (S.). The Brahman-egg; the Universe conceived as an egg, perhaps with reference to its shape, or else with reference to its contents, viz. the essence of life.

Brāhmaṇa (S.). A part of the Vedic texts which contain the regulations for the sacrificial rites and expositions of the "hymns" and the legends connected with them.

Bṛihatī (S.). Name of a metre of thirty-six syllables; used symbolically for the number 36; the earth; (dual) heaven and earth.

Chakra (S.). A "wheel." Though usually assumed to be circular, it may possess other shapes, cf. *Rāśi Chakra*. "Revolution" or "Cycle" is often meant by the term; these can, of course, be represented by any "enclosure," not necessarily circular.

Chit (S.). A pile or heap—used for the *Altar* constructed by piling up the bricks, as in *Kūrma-Chit*, etc.

Dakṣa (S.). The name of a *Prajāpati*, who gave twenty-seven of his daughters (the *Nakshatras*) in marriage to the Moon; he is identified with the Ecliptic.

Dvīpa (S.). Island.

Fuh (Ch.). A store-house; a palace; a political division.

Ho (Ch.). The Yellow River (*Hoang-Ho*); supposed to be the name of the Ecliptic or of the Milky Way; "mystic diagrams" are stated to have appeared out of this river and the river *Lo*. The name of the constellation Scorpion; also applied to its chief star Antares.

Indra (S.). The chief of the Vedic deities; identified (by Plunket) with the Summer solstice; he slays *Vritra*, the demon of drought (or the serpent) with his weapon *Vajra* (stated to be four-cornered). In later mythology he is the "king" of the gods, but was inferior to the Trinity.

Jambu (S.). The Rose-apple tree—*Eugenia Jambolana*.

Jambu-dvīpa (S.). Name of the earth derived from the notion that a Jambu-tree grew (on a slope of Mount *Meru*) at its centre; it was surrounded by seven seas and six annular lands.

Kakkab (Bab.). Star.

Kes-da (Bab.). Enclosure. Brown derives it from *Khas* = to "cut."

Ku (Bab.). "Prince" or "Leader" of the hosts, i.e. of the constellations—a term applied to Aries, earlier to Taurus, which occupied the vernal equinoctial position, and thus, at the beginning of the year, "led" the rest of the zodiacal constellations.

Kua (Ch.). A Diagram; the eight *Pa Kua* formed by combinations of three lines, one, two, or all of which may be broken or unbroken, and which are placed one above another, like ☲, ☵, etc. These are supposed to have been formed by the legendary monarch Fuhsi some four thousand years ago, inspired by the figures on the back of a tortoise; later, these were increased to sixty-four, and formed the basis of the philosophy of the Book of Changes.

Kūrma (S.). A Tortoise; the earth regarded as a tortoise.

Kūrma-Chakra (S.). "Tortoise-Wheel"—a mystical diagram connected with the *Nakshatras*.

Kūrma-chit (S.). An Altar based on the Tortoise shape; probably erected on a plan resembling the "Tortoise-Wheel."

Li, or *le* (Ch.). About one-third mile: $27\frac{4}{5}$ *li* = 10 miles.

Loka (S.). A "World," i.e. either the Universe, or one of its divisions; in particular, applied to the three or seven strata of Heaven.

Lokālōka (S.). A mythical wall of mountains surrounding the outermost region of the "visible world" and separating it from the region of darkness outside.

Loka-pāla (S.). Guardian of the World; usually there are four such regents at the four cardinal directions, though often there are four more at the intermediate directions; sometimes these are increased to 10, 14, etc.

Manzil (Ar.). (Pl. *Manāzil.*) An "alighting station" or "Inn"; the name applied to the 28 divisions of the ecliptic, the moon being supposed to rest in one station every day, during her continual travels.

Mazzāloth or *Mazzāroth* (Heb.). Supposed to mean the Signs (cf. Bab. *Mazārāti*); or Lunar Mansions (cf. Ar. *Manāzil*). Also derived from a root meaning "to watch," thus referring to the "watches" into which the days and nights were divided. Other derivations are from *Ezor* = "Girdle," and *Zāhir* (*Zuhra* = Glittering star); also used to denote the Great Bear, Sirius, the planets, etc.

Merodach (Bab.) or *Maruduk*. A Babylonian Solar deity, who fought and won against *Tiamat* and the forces of disorder.

Meru (S.). The mountain that was believed to stand at the centre of the earth, serving as an axis for celestial motion; a peak of the Himalayas; also referred to as *Su-meru* (*Su* = good), *Su-darśana*, etc.

Muhūrta (S.). A measure of time = 48 m. (30 *muhūrtas* = 1 day).

Nāḍi or *Nāḍika*. A unit of time = 24 m. (60 *nāḍis* = 1 day).

Nakshatra. A star; a star-group; one of the 27 or 28 ecliptic divisions marked by star-groups, which the moon passed every night—hence called a "lunar mansion."

Navāmśa (S.). The division corresponding to $\frac{1}{9}$ of a Sign; there are *108* of these in the circle.

Parimanḍala (S.). Globe, orbit, circumference; spherical; circular.

Prajāpati (S.). "Lord of Creatures"—a name applied to one or other of the Vedic deities regarded as supreme, like *Savitṛi*, *Soma*, *Agni*, *Indra*, etc., or to other "progenitors" like *Marichi*, *Atri*, *Vasiṣṭha*, *Dakṣa*, etc.; often identified with Time, or Sun, or Fire; the name of the 5th (39th) year in the 60 Year-cycle of Jupiter; the name by which the star δ *Aurigae* was known, and sometimes applied to the planet Mars.

Purāṇa (S.). Old legend or traditional history; a class of sacred works of the Hindus, compiled by Vyasa, the chief of which are 18 in number.

Rāhu (S.). The demon in Hindu mythology, supposed to cause the eclipses of the sun and moon by devouring them; regarded as an eighth planet in the A.V.; equated with one of the moon's nodes in the *Siddhāntas.*

Rāhu-Chakra. The eight-pointed wheel.

Rāśi-Chakra. The Wheel of Signs—the square Zodiac of 12 signs.

Sam-jñā (S.). From the root *jñā,* to "know." The name of a daughter of the Celestial Architect, the wife of the Sun, the mother of the *Aśvins.*

Siddhānta (S.). Lit. "established conclusion"; an accepted scientific treatise, especially on astronomy and mathematics.

Sieu or *Sieou* (Ch.) = Mansion; the name of the 28 lunar mansions or ecliptic divisions.

Śulva (S.). Rope or Cord.

Sūryaprajñapti (S.). A Jaina treatise on astronomy (*c.* fifth century B.C.) whose chief feature is the crude "Meru-cosmology."

Swastika (S.). The Gammate Cross.

Tvastṛi (S.). The Celestial Architect; he also made divine implements, especially *Indra's* thunderbolt.

Varuṇa (S.). An important Vedic deity.

Veda (S.). Lit. "Knowledge," the most sacred and ancient works of the Hindus, portions of which might have been composed between 4000 B.C. and 2000 B.C.—some suppose the date to be about 1000 B.C.

Vishṇu (S.). One of the *Ādityas* or Vedic Solar deities; later, he displaces *Indra* as the chief of the Pantheon; in the *Purāṇas,* he is one of the Trinity, the mainstay of the Universe. His weapon is the *chakra* or "wheel."

Yang (Ch.) and *Yin* were the two primeval forces believed to produce, by interaction, all other objects and phenomena. They were respectively the male principle and the female principle, or light and shade, or the natural and the supernatural, the sun and the moon, etc.

Yojana (S.). A measure of distance equal to 8 or 9 miles; some calculations make it 2½ miles, others 4 or 5; in one case it is nearly 18 miles.

Yuga (S.). A Cycle or period of recurrence; an age of the World, like the *Kali Yuga,* etc.

Zikum (Bab.). Heaven or Sky.

Ziqqurat or *Ziggurat* (Bab.). The "Temple-tower"—the pyramidal edifices built by the Babylonians as models of the heaven or the earth, wherein to worship the gods.

BIBLIOGRAPHY

ĀCHĀRYA, P. K. *A Dictionary of Hindu Architecture.* 1927.
"Indo-Persian Architecture," *Calcutta Review*, April 1930.

AL-BIRUNI. *India* (2 vols). Translation by Dr. C. E. Sachau. Trübner's Oriental Series. London, 1888.
The Chronology of Ancient Nations. Translation by Dr. Sachau. London, 1879.

ALLEN, R. H. *Star-names and Their Meanings.* New York, 1899.

BENTLEY, J. *A Historical View of Hindu Astronomy.* London, 1825.

BIOT, J. B. *Recherches sur l'Ancienne Astronomie Chinoise* (reprint from *Journal des Savants*, 1840).

BREASTED, J. H. *Ancient Times: A History of the Early World.* Boston, 1916.

BRENNAND, W. *Hindu Astronomy.* London, 1896.

BROWN, R. *Primitive Constellations*, etc. (2 vols.). London, 1899, 1900.
"Euphratean Stellar Researches," *P.S.B.A.*, 1892–6.

BUDGE, Sir E. A. T. W. *Amulets and Superstitions*, etc. London, 1930.

COLEBROOKE, H. T. *Miscellaneous Essays* (3 vols.). London 1873.

D'ALVIELLA, COUNT (E. Gobl t). *The Migration of Symbols.* London, 1894.

DELAMBRE, J. B. J. *Histoi e de l'astronomie ancienne.* Paris, 1817.

EDKINS, J. *Ancient Sy: ıbolism Among the Chinese.* Shanghai, 1889.
Chinese Buddhism. (Trübner's Oriental Series.) London, 1880.
"The Yi-King with Notes on the 64 kwa," *The China Review*, XII.

EGGELING, J. *Śatapatha Brāhmaṇa* (translation). *S.B.E.*, Vols. 12, 26, 41, 43, 46.

FERGUSSON, J *History of Architecture* (4 vols.). London, 1873–6.
History of Indian and Eastern Architecture. (Revised Edition.) London, 1910.

GATTY, Mrs. A. *The Book of Sun-dials.* (4th Edition.) London, 1900.

GILES, H. A. *A Glossary of Reference on Subjects Connected with the Far East.* Hong Kong, 1886.

HEATH, Sir T. L. *A History of Greek Mathematics* (2 vols.). Oxford, 1921.

HEWITT, J. F. K. *The Ruling Races of Prehistoric Times in India*, etc. (2 vols.). London, 1894–5.

HILPRECHT, H. V. *Mathematical, Metrological and Chronological Tablets from the Temple Library of Nippur.* (The Babylonian Expedition of the University of Pennsylvania, etc. Series A, Vol. 20, Pt. I.). 1893, etc.

HOERNLE, A. F. R. "The Weber MSS." *J.A.S.B.*, Vol. 62, Pt. I, 1893.

HOMMEL, F. "Uber den Ursprung und das Alter der Arabischen Stern-namen und insbesondere der Mondstationen." *Z.D.M.G.*, Vol. 45.

JENSEN, P. *Die Kosmologie der Babylonier*. Strassbourg, 1890.

JONES, Sir W. "On the Antiquity of the Indian Zodiac," *Asiatic Researches*, 1790.

KAYE, G. R. *Hindu Astronomy*. Calcutta, 1924. (Memoirs of the Archæological Survey of India, No. 18.)

Indian Mathematics. Calcutta and Simla, 1915.

KERN, J. H. C. "The Bṛihat Samhita, or Complete System of Natural Astrology of Varāhamihīra," *Verspreide Geschriften*, dl. I, 1913.

LACOUPERIE, T. DE. "The Calendar Plant of China, the Cosmic Tree and Date-Palm of Babylonia," *B.O.R.*, IV, Nos. 10, 11.

LANDSEER, J. *Sabaean Researches*, etc. London, 1823.

LAYARD, Sir A. H. *Discoveries in the Ruins of Nineveh and Babylon*. London, 1853.

LEGGE, J. *The Shu-King*. Vol. I I, *Chinese Classics*. Hong Kong, 1861–72.

LENORMANT, F. *Chaldaean Magic*. London, 1878.

LEWIS, Sir G. C. *Historical Survey of the Astronomy of the Ancients*. London, 1862.

LOCKYER, Sir J. N. *The Dawn of Astronomy*. London, 1894.

"Early Asterisms," *Nature*, Vols. 48, 49, 1893.

MACDONNEL, A. A., and KEITH, A. B. *Vedic Index of Names and Subjects*, 1912.

MACDONNEL, A. A. "Vedic Mythology," *Grundriss der indo-arischen Philologie*. Bd. 3. 1897.

MASPERO, Sir G. *The Dawn of Civilization* (5th Edition). London, 1910.

MAUNDER, E. W. "The Earth" in *The International Standard Biblical Encyclopædia*, Vol. I.

MIKAMI, Y. "The Development of Mathematics in China and Japan," 1913. (*Abhandlungen zur Geschichte der mathematischen Wissenschaften*, etc., Hft. 30.)

MONIER-WILLIAMS, Sir M. *A Sanskrit-English Dictionary.* Oxford, 1899.

MUIR, J. *Original Sanskrit Texts,* etc. London, Oxford, 1858.

MURRAY, H. J. R. *History of Chess.* Oxford, 1913.

PERROT, G., and CHIPIEZ, C. *Histoire de l'Art dans l'Antiquité* (10 tom). Paris, 1881–1914.

PETRIE, Sir W. M. F. *Egyptian Decorative Art.* London, 1895.

Decorative Patterns in the Ancient World.

PLACE, V. *Ninive et l'Assyrie . . . avec des essais de restauration,* par F. Thomas. Paris, 1867–70.

PLUNKET, the Hon. E. M. *Ancient Calendars and Constellations.* London, 1903.

PRESCOTT, W. H. *History of the Conquest of Mexico* (3 vols.). New York, 1843.

ROUT, E. A. *Maori Symbolism.* 1926.

SAYCE, A. H. *The Religions of Ancient Egypt and Babylonia.* Edinburgh, 1902.

The Astronomy and Astrology of the Babylonians (reprint from *Trans. S.B.A.*, Vol. 3, 1874).

SAYCE, A. H., and BOSANQUET, R. H. M. *M.N.R.A.S.* Vol. XL. No. 3.

SCHIAPARELLI, G. V. *Astronomy in the Old Testament.* Authorized English translation. Oxford, 1905.

SCHLEGEL, G. *Uranographie Chinoise.* The Hague, 1875.

SEWELL, R., and DIKSHITA, S. B. *The Indian Calendar.* London, 1896.

SHAMASASTRY, R. *Gavām Ayana, the Vedic Era.* Mysore, 1908.

SMITH, D. E. *History of Mathematics* (2 vols.). Boston, 1923–5.

STRASSMAIER, J. N., and EPPING, J. *Astronomisches aus Babylon.* 1889.

Zeitschrift für Assyriologie. December, 1892.

THIBAUT, G. "Astronomie, Astrologie und Mathematik" (*Grundriss der indo-arischen Philologie*), 1897.

"Babylonian Origin of the Lunar Zodiac," *J.A.S.B.*, Vol. 63, 1894.

"Contributions to the Explanation of the Jyotiṣa-Vedānga," *J.A.S.B.*, Vol. 46 ,1877.

"Sūryaprajñapti," *J.A.S.B.*, Vol. 49, 1880.

"On the Śulva-Sūtras," *J.A.S.B.*, Vol. 44, No. 3.

WALLIS, H. W. *The Cosmology of the Ṛig-Veda.* London, 1887.

WEBER, A. *Die Vedischen Nachrichten von den Naxatra.* Berlin, 1862.

Über den Veda-Kalendar. Berlin, 1862.

WEIDNER, E. F. *Handbuch der Babylonischen Astronomie.* 1915.

WHITNEY, W. D. "On the Views of Biot and Weber," etc., *J.A.O.S.*, Vol. VIII, 1864.

WHITNEY, W. D., and BURGESS, Rev. E. "Translation of the Sūrya-Siddhānta," *J.A.O.S.*, Vol. VI.

WILSON, H. H. *The Vishnu-purāṇa* (translation and notes), 1840. *Ṛig-Veda-Samhita* (translation), 1850.

WORDSWORTH, C. *The Holy Bible, with Notes*, etc. 1875.

ZIMMERN, H. *Die Keilinschriften und das Alte Testament.* 1903.

DRIVER, S. R., PLUMMER, A., and BRIGGS, C. A. (editors). *The International Critical Commentary.* Edinburgh.

HASTINGS, J. (editor). *Encyclopædia of Religion and Ethics.* Edinburgh, 1908, etc.

MAX MÜLLER, F. (editor). *The Sacred Books of the East.* Oxford, 1879, etc.

INDEX